A PREDICTIVE MODEL FOR ARCHAEOLOGICAL POTENTIAL FOR A LOCALITY IN THE INTERIOR PLATEAU OF BRITISH COLUMBIA

Damon Oriente
BLA, University of British Columbia, 1983

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Department of FOREST RESOURCES MANAGEMENT.

The University of British Columbia
Vancouver, Canada

Date 27 APRIL 2000

ABSTRACT

Consideration of heritage resources in forestry in British Columbia was mandated by the Forest Practices Code in 1993. Heritage resource planning and management in forestry, however, is often not as easily accomplished as traditional conventional scientific concerns. This is in part due to the nature of the resource. It is considered that less than half of the extant archaeological sites in the Province are known, and the physical presence of many sites are not readily apparent or are difficult to determine without physical examination.

This study utilizes normally available biophysical data in digital form to develop a predictive model for heritage potential for a locality in the British Columbia interior. A specific set of environmental criteria are selected, the study site is analyzed for areas satisfying the model criteria, and the appropriate areas are overlaid graphically to produce a predictive map. Finally, the predictive map is coregistered with data of known archaeological sites to evaluate the model.

Results from the testing overlay indicate that the area described as having high archaeological potential contains 73% of the currently known sites. These results suggest a positive relationship between the combination of the selected environmental criteria and the location of known sites for the study area.

The paper includes research into other predictive models and related archaeological literature, an overview of interior British Columbia pre-history, and reports on consultation with Native Indian persons who live in the area.

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Finally, my wife and family have supported me throughout this work, and I am very grateful for their good advice and good humour over the past five years.

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SECTION ONE

PROLOGUE

1.1

Conditions of Study

The scope of this paper has been confined by the distribution restrictions on archaeological resource information. Maps, databases, and locations of historic and prehistoric sites are classified, and may not be distributed to the general public without express permission of the Archaeology Branch, Ministry of Small Business, Tourism and Culture (MSBT&C). Permission to use the archaeological information was provided to the author with the following conditions:

> The use of this site information in reports, publications, or information releases shall acknowledge the Archaeology Branch as the source.
>
> Strict data security must be maintained. Access to data, particularly exact site locations, should be limited to those who absolutely need to know. When the information has been used for the purpose specified in the "British Columbia Site Information Request Form" all original data must be destroyed unless other arrangements have been made with the Archaeology Branch (Archaeology Branch).

These security restrictions limited the extent of information provided by the Branch for the modeling exercise described in the paper which follows. Details of site types, exact locations, size, or significance are present infrequently in the archaeological database provided by the

Branch. It is also true that in many cases, detailed information is simply not available, thus the gaps in the database. Where this information is provided, I am obligated to avoid any disclosure which may put archaeological sites at risk as a consequence of specific references to locations. Access to location information must come through the Archaeology Branch exclusively.

Terrain resource inventory map (TRIM) data for this work was provided by the Lillooet Tribal Council geographical inventory system (GIS) and Mapping Office. Their contribution to this work is important, and this paper should be seen as a cooperative, academic study. Conditions were also placed on the use of this information by the Tribal Council staff that affect its distribution and potential interpretation. Provision of the base data to me was dependent upon my personal assurance to the Tribal Council that:

- there be no public distribution of the final product
- no known sites be identified in such manner that their locations become easily determined
- the work of the study not be presented as prejudicial to aboriginal rights or title.

LIST OF ABBREVIATIONS

1.2

BP	Before Present
CHIN	Cultural Heritage Information Network
CMT	Culturally Modified Trees
DEM	Digital Elevation Model
HCA	Heritage Conservation Act
IDF	Interior Douglas Fir
IWF	Interior Western Hemlock
GIS	Geographic Information System
MSBT&C	Ministry of Small Business, Tourism and Culture
MOE	Ministry of the Environment
TRIM	Terrain Resource Inventory Map

UTM	Universal Transverse Mercator
FPC	Forest Practices Code
LRMP	Land and Resource Management Plan

SECTION TWO

INTRODUCTION & BACKGROUND TO THE STUDY

2.1

Introduction

As the worldwide demand for wood and wood fibre products grows, the demands on forests worldwide increases. Concurrently, there is a growing recognition of the economic and scientific values inherent in forests which are adjunct to timber and fibre. As a result of this awareness, there is increasing scrutiny among developed nations on countries such as Canada, which have both extensive forest lands and substantial economies based upon harvesting of timber. Canadian forestry managers have responded by broadening the range of non-timber interests included in general forest management. One important area of consideration is physical and cultural heritage resources. Where physical resources exist, they are often central to traditional cultural concerns. At the same time, physical heritage areas are often difficult to accommodate within traditional forestry operations, already increasingly constrained by variable economic conditions.

This paper contains the background, development, application, and testing of a predictive model designed to aide heritage resource planning and management in mainstream forest practice. The goal of this thesis is to produce a model to predict areas of high archaeological potential for a site adjacent to the Fraser River in the interior plateau of British Columbia. Although tested on a specific site, I anticipate that the model format, process, and criteria may be relevant over a broader range of sites.

The model is intended to be a front-end planning model; it is not a prospecting tool with which to locate artifacts. It is based on a set of physiographic criteria which are considered to be effective in establishing areas of probable historic significance. It is proposed that an effective predictive model may be developed using a relatively small set of modeling criteria, provided that the criteria are appropriate to the regional environment and ethnographic history.

The form for the model follows generally a number of other archaeological models developed in Canada, as well as in the United States and Europe. Modeling criteria shown to be effective in other predictive studies were reviewed and a subset adapted to the study area where appropriate. The model exercise is built on Terrain Resource Inventory Map (TRIM) data. Relevant First Nations persons verified the modeling criteria as appropriate to the study area and goals. Academic research and personal experience contributed to the resolution of the model.

2.2 *Historical Background*

The present area of British Columbia has been inhabited by native peoples whose range covered most of the province, and whose history of habitation and land use dates from perhaps 12,000 years BP. (Fladmark, 1986). For early peoples, much contemporary understanding and detailed knowledge of their lifestyle comes largely from archaeological research.

For extinct peoples, the physical record is essential; it is the only remaining information link we have with the past. For contemporary Indigenous peoples who have retained their language, their oral tradition provides a significant advantage. However, oral records and the native tradition of legends and stories may not always be relied upon as consistent or unbiased records of traditional land use patterns. Diane Reed (pers. comm.[1]), of the Squamish Forest District reports that during a recent archaeological overview assessment conducted by Millennia Research (Muir *et al.*, 1994), field tours directed by native elders yielded no physical traces of traditional land use.

There are written records also, produced by early European ethnographers. Boas, Dawson and Teit are frequently referenced (Hayden, 1992, Fladmark, 1986). Their work adds to the historical information available on natives in the later stages of European contact.

The era of early European contact, from 1750 to 1895 (Hayden, 1992), witnessed the greatest changes to the traditional lifestyles of Indigenous peoples. Many traditional patterns of living became diluted, and replaced by new patterns of trade, and by new products of trade. For example, the supplying of furs to trading companies became a significant occupation, which often replaced hunting and gathering (Fladmark, 1986). Researchers such as James Teit recorded current conditions and lifestyles of native peoples at the turn of the century. His records are considered to be remarkably objective for their time (Muir *et al.*, 1994, Hayden, 1992). His records are, however, occasionally criticized as biased and condescending by modern native persons. The general position of the Indigenous peoples appears to be that no European records are reliable. In my own experience, First Nations persons have stated specifically that "non-native records and historians are unable to adequately portray the history of aboriginal peoples" (Chief Terry Porter, pers. comm.[2]).

It may be concluded then, that native legend and oral tradition as well as early European records are subject to inaccuracies or embellishment over time. As such, reliance on these sources for historic or prehistoric prediction may augment, but not replace, a more objective basis for predictive modeling.

1. Ministry of Forests Office, Squamish Forest District, September, 1997.
2. Band Chief, Bonaparte Indian Band, at Hat Creek Ranch, October, 1997.

2.3 *Summary*

I believe that there exists a need for those involved in forest resource management to have a planning model for prediction of areas of archaeological content. The model proposed in this thesis is based upon available, existing map data. It relies on anthropological oral records only in terms of research into the factors incorporated by the model.

This document is divided into seven sections. Section three presents the model and outlines primary background research supporting the development of the model. Key features of other predictive models reviewed are noted, and conclusions of background research are summarized. Section four describes the study area and materials used. In section five I present the methodology of the model, and the first data manipulation maps. The results of the modeling are given in section six. Included in this section are mapping results produced by application of the model design. Section seven discusses the results and processes, and section eight concludes the paper.

More extensive reporting of background research may be found in the appendices. Appendix one summarizes additional ethno-archaeological site information by researchers whose work in an area adjacent to the study area contributed to the formation of this model. Appendix two provides a brief introduction to the prehistory of British Columbia specific to the interior plateau region. Emphasis is given to the Keatley Creek pit house site. Appendix three adds supplementary model type definitions. Appendix four relates database fields, as part of the Cultural Heritage Inventory Network (CHIN), as supplied to me for topological links of the archaeological spatial data.

S E C T I O N   T H R E E

MODEL DESCRIPTION, BACKGROUND & DEVELOPMENT

3.1

The Predictive Model

The model developed in this thesis is built upon the concept that environmental conditions influenced the land use patterns of prehistoric peoples. Responses to the environment would be seen in settlement and shelter, clothing, food gathering habits, and in cultural traditions (Knowles 1974). It is proposed that environmental factors substantially directed land use of ancient peoples. In some situations, the imprint of traditional land use may still be seen upon the land. These imprints may be intentional modifications or unintentional 'wear patterns'. Where these modifications remain visible or artifacts exist, they form part of the archaeological record which exists today.

For this model, three primary environmental factors are used: slope, aspect, and proximity to water. The concept of the model is straightforward; areas of the study site which satisfy each of the basic criteria are graphically superimposed, and the resulting area is mapped for archaeological value. Figure 3.11 illustrates the essential process.

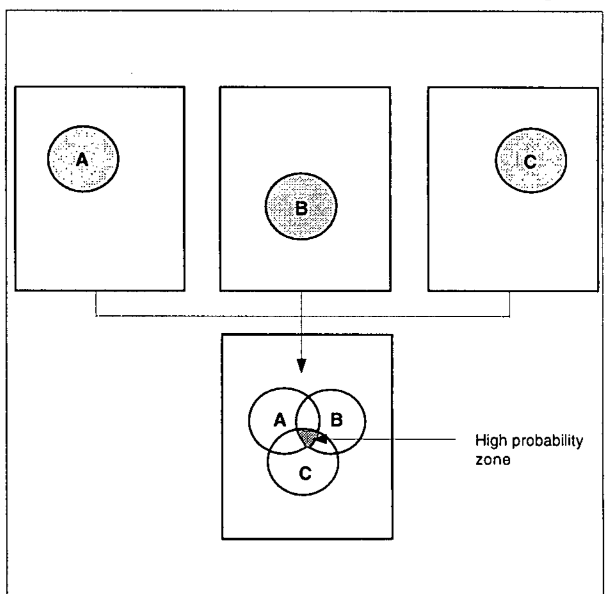


Fig 3.11 Conceptual Model Form & Process

For this model, each criterium is considered to contribute equally to determination of suitable sites. As such, each criterium individually can influence site selection, but the positive combination of criteria, seen above as the area of intersection between A, B, and C, will characterize the areas most frequently chosen.

The model itself is developed upon the following standards. That:

- base data be available with reasonable ease to the forestry industry
- base data be available in a usable format
- the model be workable with a minimum of reliance on personal experience or oral records.

When complete, the model is intended to satisfy the following objectives:

- the model maximize its usefulness by being compatible with the existing forest information system
- the modeling procedures be explicit and repeatable
- the model be effective in indication of a majority of areas of valid heritage resource in a minority of the land base in the study area.

In establishing the scope of this work, boundaries must be created, limiting the extent of material considered. The model set out here is limited to mapped, bio-physical data. No new base information was collected; as noted earlier, one goal of this work is to use publicly available, digital data.

It is acknowledged that this excludes substantial areas of related research.
The most important of the exclusions inherent in the model include:

- oral tradition and legend
- First Nations spiritual sites and studies
- culturally modified trees(CMT)

This is not meant to diminish the importance of oral tradition in any way. Although without a traditional written language (Fladmark, 1986), the aboriginal peoples of British Columbia developed a vital and extensive oral tradition, with many practical and spiritual traditions well covered by this method of learning. However, as noted in the introduction, this learning may not always be reliable or testable. In addition, it is often not available information, and as such may not be integrated easily into a modeling system intended to be repeatable or transferable.

3.2 Background

The model developed for this work was motivated by three factors; the first is a genuine personal interest in archaeology and and concern for the responsible management of heritage resources. The second is the recognition that heritage assessment requirements of the forest practices code are, in many cases, difficult to implement in daily forestry practice. The third is the hypothesis that prehistoric land use was closely related to environmental influences upon prehistoric peoples. Following from this last assumption, it may be reasonable to assert that a model based upon environmental factors can be developed which would reliably predict areas of relative archaeological potential.

Current forest land planning and management is based upon Terrain Resource Inventory Map (TRIM) data maintained by the Ministry of Environment, Lands and Parks (MOELP). Forest cover information, maintained by the Ministry of Forests (MOF), augments TRIM data. While differing in scale from TRIM maps, forest cover data are considered to be compatible with MOELP information. Consequently, a model using TRIM data would utilize reasonable available data, and would be subsequently easy to include in the provincial land information system.

3.3 Forestry Practice

In British Columbia, historic sites may be grouped into three general location classes: sites currently under modern cities, sites underwater, or, the largest group, sites in forest and range lands. It is a fact of contemporary administration that the majority of British Columbia archaeological sites fall under the effective control of the Ministry of Forests. Furthermore, it is inevitable that a great number of sites will be discovered, and respected or put at risk, by the field workers of forestry and resource companies.

Several conditions exist which make accommodation of archaeological resources difficult for forestry operators. As a first condition, the issue of heritage site definition and recognition presents difficulties. Principally, heritage sites include pre-contact and post-contact sites. Roads, wood buildings and foundation remnants, pit houses, burial grounds, structures created at hunting and fishing sites, and culturally modified tree locations are some examples of heritage resources. Additionally, some persons consider areas of traditional use as heritage sites. As such, simply recognizing (and agreeing upon) heritage sites may be difficult and require heritage specialists or negotiation. To exacerbate this situation, the forest industry considers there to be a lack of persons skilled in efficient management of heritage sites (pers. comm. Karen Jarvis[3]). Once the resource is defined, no persons are easily available to advise the operators; because the sensitive areas are very often below ground, their extent, value, and sensitivity are hard to assess, even for experienced persons. Depending on the nature of the physical site, ultimately, objective data are scarce or their interpretation questionable.

This situation leads to the second concern relating to archaeological sites. Archaeological sites and archaeology often defy easy, linear scientific interpretation (Kelly and Hannen, 1988). In some situations, physical features are simply not explainable (Anthony Barratt, pers. comm.[4]). Continued study may require a great deal of time, and, in some cases, there is ultimately very

3. Pacific Forest Products, Honeymoon Bay, 1996.
4. The Lunt Roman Fort, archaeological excavation, Warwickshire, England, August 1995

little evidence present upon which to make interpretative reports or recommendations. Obtaining further evidence may require some specialized study or testing, which, if needed during active operations, will cause a delay in operations. Forestry companies understandably have more access to persons who may deal with traditional silvicultural issues than with heritage issues. Thirdly, forestry operations persons are often reluctant to have additional administrative obstacles added to their work. The suspicion alone of the presence of a culturally significant site can easily cause delays in forest operations, and may add significant cost to those operations (pers. comm. Karen Jarvis. [5])

First Nations have expressed concern about forestry activities and their potential for damage to heritage sites (Chief Terry Porter, pers. comm. 1997[6]) and so are in agreement generally that heritage concerns be included as part of general forest management. However, First Nations persons themselves are not always aware of the full extent of resources which may be present, as oral traditions, and land use habits, change over time. In addition, First Nations are understandably reticent to have the locations of traditional use sites become public knowledge. Many persons consider collection of artifacts to be a hobby, in spite of the legislation prohibiting the disturbance of heritage sites and artifacts. This can make the delineation of heritage areas unwise, as it may put sensitive sites at risk.

3.4 Legislation

In British Columbia, there are several levels of legal and administrative control over cultural resources. Management of cultural resources and heritage sites is administered jointly by the Ministry of Small Business, Tourism and Culture, and the Ministry of Forests (MSBT&C, B.C. Govt. Protocol Agreement, 1994). Within MSBT, the Archaeology Branch is directly responsible for the management of archaeological sites, whereas the Heritage Conservation Branch is responsible for managing historic buildings and overall management policy. Cultural sites and

5. Pacific Forest Products, Honeymoon Bay, 1996.
6. Hat Creek Historic Ranch, 1997.

resources owned, developed or operated by the Province are handled by the Heritage Properties Branch, MSMT&C.

There are two important statutes regulating heritage sites in British Columbia. Overriding other legislation is the Heritage conservation Act, 1979, Chapter 165 (B.C. Govt. Heritage Cons. Act, 1994). This act, amended in 1994 by Bill 21, applies to all heritage sites in British Columbia, whether on public or private property. The act prohibits the destruction, damage or excavation of any archaeological site without a permit. The act also authorizes the Minister, or designate, to order a site survey if it is believed that a site may be of archaeological importance. The HPA provides the following definitions:

> "heritage object" means, whether designated or not, personal property that has heritage value to British Columbia, a community or an aboriginal people;
> "heritage site" means, whether designated or not, land, including land covered by water, that has heritage value to British Columbia, a community or an aboriginal people;
> "Provincial heritage site" mean a heritage site designated under section 4 or a Provincial heritage property established under section 9.1;
> "alter" means to change in any manner and, without limiting this, includes
> (a) the making of an improvement, as defined in the Builders Lien Act and
> (b) any action that detracts from the heritage value of of a heritage site or a heritage object
>
> (section 13)

The second important piece of legislation concerning heritage resources in forest land is the Forest Practices Code (British Columbia 1995). In addition to setting silvicultural and procedural standards, the Forest Practices Code (FPC) includes heritage resources as factors to be considered in the planning of forest operations: The FPC provides the following definitions:

> Resource Values: "Products or commodities associated with forest lands and largely dependent on ecological processes. These include, but are not limited to, water quality and quantity, forage, fish, wildlife, timber, recreation, energy, minerals, and cultural and heritage resources" (p 110)
>
> Heritage areas: "Sites of historical, architectural, archaeological, paleontological, or scenic interest to the province" (p 105).

Congruent with the Heritage Conservation Act, the Forest Practices Code requires that forest operations be stopped or modified immediately when previously unidentified heritage features, such as archaeological sites, are discovered. This requirement is intended to minimize damage or disturbance to historic resources until operations can be revised or protective measures taken. The code also recognizes the rights of aboriginal peoples as affirmed under the Constitution of Canada. This code means that Aboriginal rights cannot be infringed by activities of the Crown, which includes tenures, licenses, or leases concerning forest operations.

Taken together, the Heritage Conservation Act and the Forest Practices Code set in place a framework which creates a need for improved archaeological and heritage management which is effective in active forest management. The predictive model which is the goal of this study aims to contribute to such a system.

3.5 Model Development

The development of the predictive model presented here is based on a combination of reviews of anthropological information, related predictive models, and consultation with native Indian groups.

3.6 Literature Reviewed

Many sources of ethnographic and archaeological information and history relevant to the study area were reviewed. Several important references are noted in this section.

Not all sources are conventional 'scientific' literature, however. In the novel *Robinson Crusoe,* Daniel Dafoe (1750) deposits his unfortunate Crusoe on an island, and leaves him with the minimum of contemporary tools. Robinson Crusoe is reduced to basic and primitive conditions, and must provide himself with both food and shelter. Describing his search for suitable habitation Crusoe reports

> I soon found the place I was in was not for my settlement, particularly because it was upon a low moorish ground near the sea, and I believed would not be wholesome; and more particularly because there was no fresh water near it. So I resolved to find a more healthy and more convenient spot of ground.
>
> I consulted several things in my situation, which I found would be proper for me. First, health and fresh water, I just now mentioned. Secondly, shelter from the heat of the sun. Thirdly, security from ravenous creatures, whether men or beasts. Fourthly, a view to the sea, that if God send any ship in sight I might not lose any advantage for my deliverance, of which I was

not willing to banish all my expectations yet.

> In search of a place proper for this, I found a little plain on the side of a rising hill, whose front towards this little plain was steep as a house-side, so that nothing could come down upon me from the top; on the side of this rock there was a hollow place, a little way in, like the entrance or door of a cave; but there was not really any cave, or way into the rock at all.
>
> On the flat of the green, just before this hollow place, I resolved to pitch my tent. This plain was not above an hundred yards broad, and about twice as long, and lay like a green before my door, and at the end of it descended irregularly every way down into the low grounds by the seaside. It was on the N.N.W. side of the hill, so that I was sheltered from the heat every day, till it came to a W. and by S. sun, or thereabouts, which in those countries is near the setting.

Dafoe's description of Robinson Crusoe's thoughts are of interest as a list of what the basic considerations for safe shelter might be when one is in the most basic of circumstances. I believe that it also describes the condition of one who is unable to make substantive change to the environment and so must adapt by finding the most suitable location for habitation and activities. This concept, stated explicitly by Knowles (1974), is is central to the model proposed in this paper.

Hayden (1992), has conducted considerable academic and on-site research into the ethnography of the prehistoric peoples of the interior. Specifically, he has directed excavations at Keatley Creek. Located on an east river terrace above the Fraser River, this site is one of the largest pit-house sites known. Additional information on pit houses is found in Appendix Two.

Rousseau and Klassen (1995) have produced an archaeological inventory and assessment of the Hat Creek Ranch, located just to the north of the present town of Cache Creek. This report includes ethnographic research and is focused on assessing the extent of the heritage resource in that area. It is not predictive of any remaining resource.

Fladmark (1975, 1986) provided academic ethnoarchaeological information relating to interior and coastal Aboriginal peoples.

Summaries of the general climactic and vegetative changes affecting the study area proposed are consistent in works by Hayden (1992), Fladmark (1986) and others.

Hannen and Kelly (1988) published a book examining archaeological theory and practice in consideration of scientific methodology and theory.

The background material listed here provided a general understanding of prehistoric peoples, subsistence habits, land use traditions, and environmental conditions. Each of these sources provided information which contributed to the development of the model proposed here.

3.7 Related Archaeological Models and Studies

During the planning of this work many archaeological predictive models and related studies were consulted. Models from British Columbia, Canada, and other countries were reviewed. Not all appear intended to predict new sites on a landscape level. Most work seems, in fact, to be oriented towards examination of artifact distribution, statistical evaluation of characteristics of known sites, or simply towards inventory. Very brief summaries of a selection of models reviewed are in the following section.

3.8 British Columbia Predictive Models

Eldridge and Mackie (1993) produced a report summarizing archaeological inventories and modeling in British Columbia. This is an overview of completed modeling, assessments and inventory projects, rather than a specific study. Key recommendations from their report include:

- separate modeling methodologies for coastal areas and interior regions
- evaluation of GIS models be based on comparison with judgmental models
- 1:50,000 be considered as the smallest scale for predictive models and maps
- probability maps be part of the product of predictive reports
- better environmental base information is required for the Province as a whole.

Regarding the size of the known and potential heritage resource in British Columbia, they note that "It is conservatively estimated that 16,000 prehistoric archaeological sites occur along the coastline of the province of which about 5,000 have been recorded. In the interior of the Province, probably at least 70,000 archaeological sites exist, of which only 9,000 are recorded. *The numbers for the interior could be underestimated by an order of magnitude*" (my italics). They later conclude "It is estimated that at least 100,000 prehistoric sites occur in British Columbia". The contradiction in numbers serves to illustrate the potential extent of the resource.

Muir *et al.* (1994) completed an archaeological overview of the Kamloops Land and Resource management Plan (LRMP). This LRMP borders the eastern side of the recorded archaeological site data sheet used for this study. Primarily an overview that assembled known data, it also includes ethnographic research which is used to assess archaeological resource potential for the LRMP. Their potential extends as far as general expectations of site densities, without actually mapping areas of relative potential. Their work includes the following list of site selection criteria "...very likely used by all native groups to select a suitable place for a camp or village...

- dry, level camping ground
- availability of trees for fuel
- proximity to potable water
- the abundance, variety, and accessibility of local food resources
- access to trade and transportation routes."

My personal discussions with local native persons (see section 3.12 following) suggests a different order of importance, but support the criteria generally. This ethnographic research by Muir et al. (1996) resulted in traditional land use being related to environmental land units for their study. These units are noted in Appendix One.

Scott *et al.* (1994) produced a GIS-based predictive model for a small section of the west coast of Vancouver Island. Their work looked at known sites within a 100 metre strip of shoreline, and they limit the extent of applicability of their model to this narrow corridor. No predictive map was included in the distributed report.

3.9 Other Canadian Models

Dalla Bona (1994) has developed a predictive model for the Thunder Bay District of Ontario. He applied his model to three sites of known prehistoric activity, Brightsand, Abitibi, and Black Sturgeon Lake, all near Thunder Bay Ontario. These studies, built upon a raster- based GIS, utilize the following environmental variables: proximity to water, soils, drainage, slope, aspect, landform, and topography.

Finnigan (1994) reports on a GIS model using slope, aspect, proximity to water, hydrology, soils, and presence of trails. Study blocks were sampled on the ground, and all factors combined in equal weights.

3.10 International Models

At Rutgers University, Chapel Hill, North Carolina, Drs. Scott Madry and Carole Crumley (1995) are heading a study which is conducting both predictive modeling as well as excavation and inventory in the Arroux River Valley in France. Their work concentrates on Roman and Iron Age archaeological remains. Their model concentrates on topographic features, considered important from military or defensive perspectives, slope, aspect, and line-of-sight analysis. Additionally, they have digitized historic maps for inclusion into their information layering.

Knowles (1974) has modeled settlement sites of the Piute Indians in California's Owens Valley. His work is an early computer based model which analyzes the influence of "environmental stress factors": water, slope, aspect, wind, soil type, and known transportation routes.

Carmichael (1990) looking at distributions of known prehistoric sites in Montana, used a GIS model which was heavily dependent on statistical analysis. His study was not purely predictive, but used characteristics of known sites in conjunction with known non-site control points to determine if significant differences existed which could be shown to be strongly associated with archaeological sites (site type not indicated).

3.11 Summation of Results of Models Reviewed

Generally, a predictive model is considered a success if the results indicate detection of sites with greater reliability than chance guessing (Eldrige and Mackie, 1993). Reviewing the literature of existing predictive exercises, the following levels of predictive accuracy were reported:

Eldridge and Mackie (1993) cite Warren (1990) who in a study in Colorado reports correctly identifying 67% of the sites on 61% of the land base. No further details are provided. They also refer to Carmichael (1990), again in Colorado, reporting on a model which correctly identifies 72% of sites in 45% of the land base.

Dalla Bona (1994) used weighted criteria with a graphical overlay system, and rated archaeological probability on a numerical scale. With result values ranging from 20 to 149, cells with the highest values are highest in potential (no other classification is provided). In the Brightsand area, 10 of the 11 known sites were located within the high probability area. At the Abitibi site, one of four known sites was located within the high probability zone. For the Black Sturgeon Lake study, 32 known sites exist, but no report of correctly located sites is provided. He notes here that 80% of the total site area is within the high probability zone. For each of these studies, Dalla Bona (1994) indicates that the number of known sites is too low to provide any reliable statistical analysis.

While Dalla Bona does describe his weighting system, there is no justification provided for the weighting used. In addition, he gives no indication of how the data he used was obtained. His comparison of 'known site' characteristics with 'known non-sites' characteristics uses areas which have no recorded sites. One may caution that with investigation some of these non-site areas may in fact contain some archaeological remains or have some archaeological value. Thus the assumption of 'known non-sites' could be disputed or altered with further examination .

Scott (1994), in his coastal British Columbia study, used three criteria and applied them to a very limited area. A map of the model application is provided in the report, but he gives no area or percentage figure of land area as included or excluded from archaeological potential by the model. He does state that, using statistical evaluation of site characteristics, the model predicted two of six sites, and six of six non-sites correctly, resulting in an accuracy rate of 66.7% (his figure). He states that this is comparable to other studies (Carmichael, 1990) referenced, noted next.

Carmichael (1990), in his Montana study, does not enumerate his precise results. He suggests the results he expects, but does not actually provide those results. His reported expectation is that 72 percent of sites should occur in 45 percent of the study area.

Warren (1990) mentions briefly a statistical study similar in methodology to Carmichael above, which correctly identified 60 percent of sites (no area given).

Finnigan (1994) states " At the highest accuracy level, the first year model indicated that 90% of the sites were located within 60% of the habitable land (excludes land covered by water). If the desired accuracy is lowered, the model predicts that 62% of the sites are located within 28% of the habitable land."

Considering other studies reviewed here, it should be noted that specific site types are rarely noted in these works, and so it is not possible to draw any correlation between predictive ability and any particular site type or size classification. It appears consistent among general archaeological studies that all physical evidence is treated equally by the studies reviewed. Dalla Bona (1994) makes this point explicitly: in his work, a find of an isolated lithic fragment is considered a site.

3.12 Consultation with Native Indian Groups

Planning and Interpretative programming work at the Hat Creek Ranch (Oriente and MacFarland, 1997) and, later, contact with the Lillooet Tribal Council allowed for direct discussions with First Nations persons regarding the appropriateness of the model generally and the modeling criteria in particular. The Bonaparte Indian Band is located near Cache Creek, approximately 50 kilometres east of the study area Chief Terry Porter (pers. comm.[7]) related the following general points:

- that many areas and landscapes had traditional uses
- the river valleys were important travel routes for both prehistoric peoples and for

7. Hat Creek Ranch, August 1997

early European settlers

• food gathering and processing occurred along rivers in conjunction with fishing

• settlement sites were high, away from rivers, with sunny aspect and protection from wind.

Larry Casper and Randy James of the Lillooet Tribal Council provided site specific ethnographic information. Larry Casper (pers. comm.[8]) related the following list of environmental factors and their probable influence on traditional land use:

• protection from wind and a sunny aspect were critical to location of habitation sites

• potable water in close proximity was essential to all camping and habitation sites

• mountain-top lookout sites were exempt from the water requirement as these locations were supported by other community members

• alpine sites are numerous, but very few are recorded (site type not explicitly stated)

• habitation sites were generally central to several areas of resource procurement

• the Fraser River provided seasonal food, but not drinkable water; the Keatley Creek site was not considered too far from the Fraser River, considering the River as a food source.

3.13 Conclusions of Background Research

It is my opinion that there is a general concurrence among existing work that predictive exercises may be built upon a relatively simple set of environmental factors. Dalla Bona (1994), notes that "In fact, ... the location of every site in the sample area can be explained by association with these three variables (soil types, vegetation, and proximity to navigable water). Although the specific variables used are adjusted or weighted for various regions, the use of a simple set of variables is generally consistent.

8. Lillooet Tribal Council Office, Lillooet, November, 1997

Models which have attempted further to refine modeling factors by assigning relative weighting do not seem to achieve any greater differentiation or accuracy. In fact, no model reviewed for this work attempted to move beyond the indication of areas as 'high', medium', or 'low' potential. This observation includes Canadian and international studies. Some models simply indicate 'some potential' versus areas of 'no potential', with apparently equal predictive power. The Eldrige and Mackie study (1993) uses this boolean system in its final predictive map.

Regarding theory, my research suggests that most models are built upon three general assumptions.

1. that prehistoric land use was strongly influenced by environmental factors.
2. the assumption that current information sources of environmental data reasonably reflect, or allow extrapolation of, prehistoric environmental conditions. This is consistent with the research performed by Dalla Bona (1994) and Warren (1990).
3. That that modern researchers may, with ethnographic and anthropological assistance, reasonably ascertain prehistoric cultural responses to environment.

This third assumption becomes more mathematical as well as more varied in models which weight the numerical influences assigned to specific environmental factors. I believe that modern valuation of relative responses to environmental stress by prehistoric peoples must be considered as untestable.

Regarding methodological issues, the theoretical assumptions appear to result in similar methodologies for many models. The following general characteristics appear consistent among models reviewed for this work:

- predictive models concentrate on physical archaeological evidence
- most make use of a limited number of criteria
- criteria values appear to be taken from a limited number of information sources

As illustrated on the first page of this chapter, the model methodology presented in the following chapter is based on a graphical overlay of several sets of spatial data. The methodology is consistent generally with other current predictive models. The criteria used are supported by the review of other modeling work, relevant anthropological research, and personal experience and communications with First Nations persons in and around the study area.

SECTION FOUR

STUDY AREA & MATERIALS

4.1

Study Area

The 162 square kilometre study area straddles the Fraser River, approximately twenty kilometres north of Lillooet. It is the southwest quadrant of National Topographic Survey (NTS) map sheet 92I/13 (Fig. 4.11). The precise study area is covered by TRIM map 92I/181, at a scale of 1:20,000. The Fraser River is its lowest point, at approximately 240 metres. The land rises on each side of the river; west of the river, the highest point of land reaches 2011 metres.

The Fraser river is joined by Pavilion Creek which flows from Pavilion Lake, and has its head at the west boundary of Marble Canyon Provincial Park. Other mapped and named watercourses within the study area are Tiffin Creek, Keatley Creek, Blackhill Creek, Lee Creek, and Slok Creek.

The lower elevations of the study area contain the Bunchgrass biogeoclimatic zone (Krajina, 1954, MOF, 1992b). This zone reaches its northern-most extent in this section of the Fraser River valley, just south of the confluence of Pavilion Creek and the Fraser River. South of the Bunchgrass zone, the Ponderosa Pine zone and Interior Douglas Fir biogeoclimatic zones are extant above 800 metres. Where not cultivated, river terraces along the Fraser are covered primarily by grasses. At intermediate elevations, ponderosa pine (*Pinus ponderosa* Laws.)

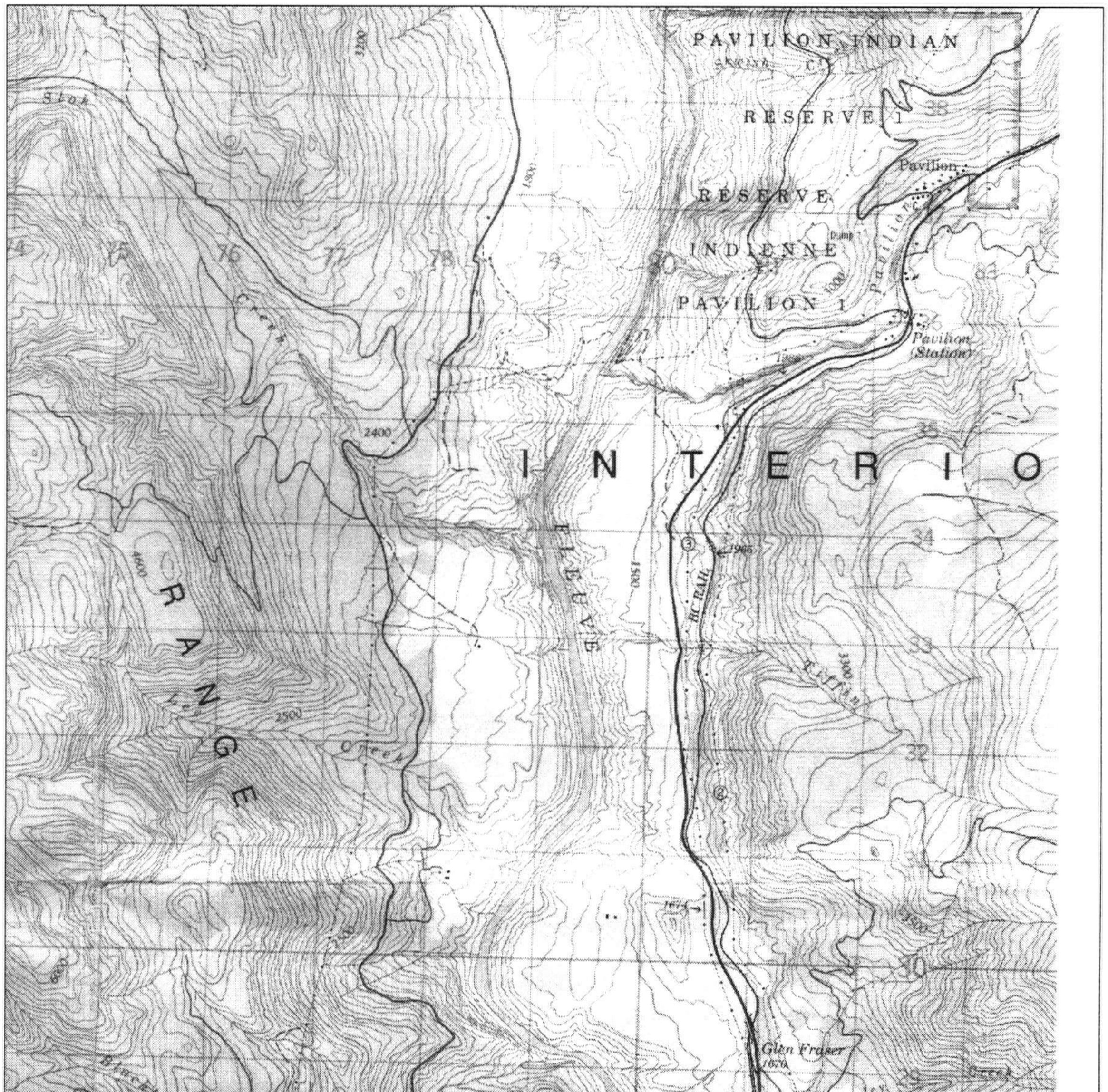


Fig 4.11 Portion of NTS Map Sheet 92I-13

occur with bunchgrass (*Agropyron spicatum* (Parsh)), and rabbit brush (*Chrysothermnus nauseous* (Pull) Britt.). At higher elevations, ponderosa pine gives way to Douglas fir (*Pseudotsuga menziesii* var. *glauca* (Bessin)) over intermediate slopes of till over rock.

Fig 4.12 Air photograph with Lakebed Terraces approximately Indicated in Red

Along the Fraser River canyon, substantial sand and gravel river deposits have formed river and lakebed terraces, which have eroded extensively over time. At approximately 425 metres elevation, silty lake bed terraces are apparent both from the highway through the valley as well as from aerial photographs. Aerial photographs display clearly the characteristic erosion pattern of lake bed terraces, Fig 4.12.

DATA	SOURCE	DESCRIPTION	SCALE	ILLUSTRATION
TRIM	Lillooet Tribal Council	contours	1:20,000	Fig. 4.22
		hydro transmission lines	1:20,000	
		roads	1:20,000	
		rivers	1:20,000	
		spot elevations	1:20,000	
		landcover	1:20,000	
Database	Lillooet Tribal Council	Spatial and Attribute data		
Air Photos	Maps B.C	Stereo pairs	1:40,000 approx	Fig 4.24
NTS	Retail map store	Site and Context, paper	1:50,000	Fig 4.11
Archaeology	Archaeology Branch	Recorded historic sites	1:50,000	Fig 4.23
Database	Archaeology Branch	Spatial and Attribute data		Fields only, Apndx.

Fig 4.21 Table of Data Types, Descriptions, and Sources

4.2 *Study Data: Sources and Characteristics*

Selection of a study area was based upon several issues. The central issue was availability of base environmental data and meaningful archaeological data. In addition, it was necessary that these data be available in a format which would be easily usable. Fig. 4.21 lists the data characteristics and sources.

Modern translator programs have made conversion from a variety of common file formats a routine procedure. Thus TRIM data, as available from a variety of government sources, are both available and suitable. Both the TRIM data and archaeological data used here are registered to the NAD 83 projection, using UTM coordinates. TRIM data provided by the Lillooet Tribal Council[9] was furnished on a temporary basis. As provided, these are shown in Fig. 4.22. Spot elevation data were very sparse, with the file having only 45 elevations for the entire area. The data sets were derived from working files in use by the Band. Some alterations, additions or omissions from the original TRIM data set are possible.

9 Lillooet Tribal Council Office, Lillooet, British Columbia, 1997.

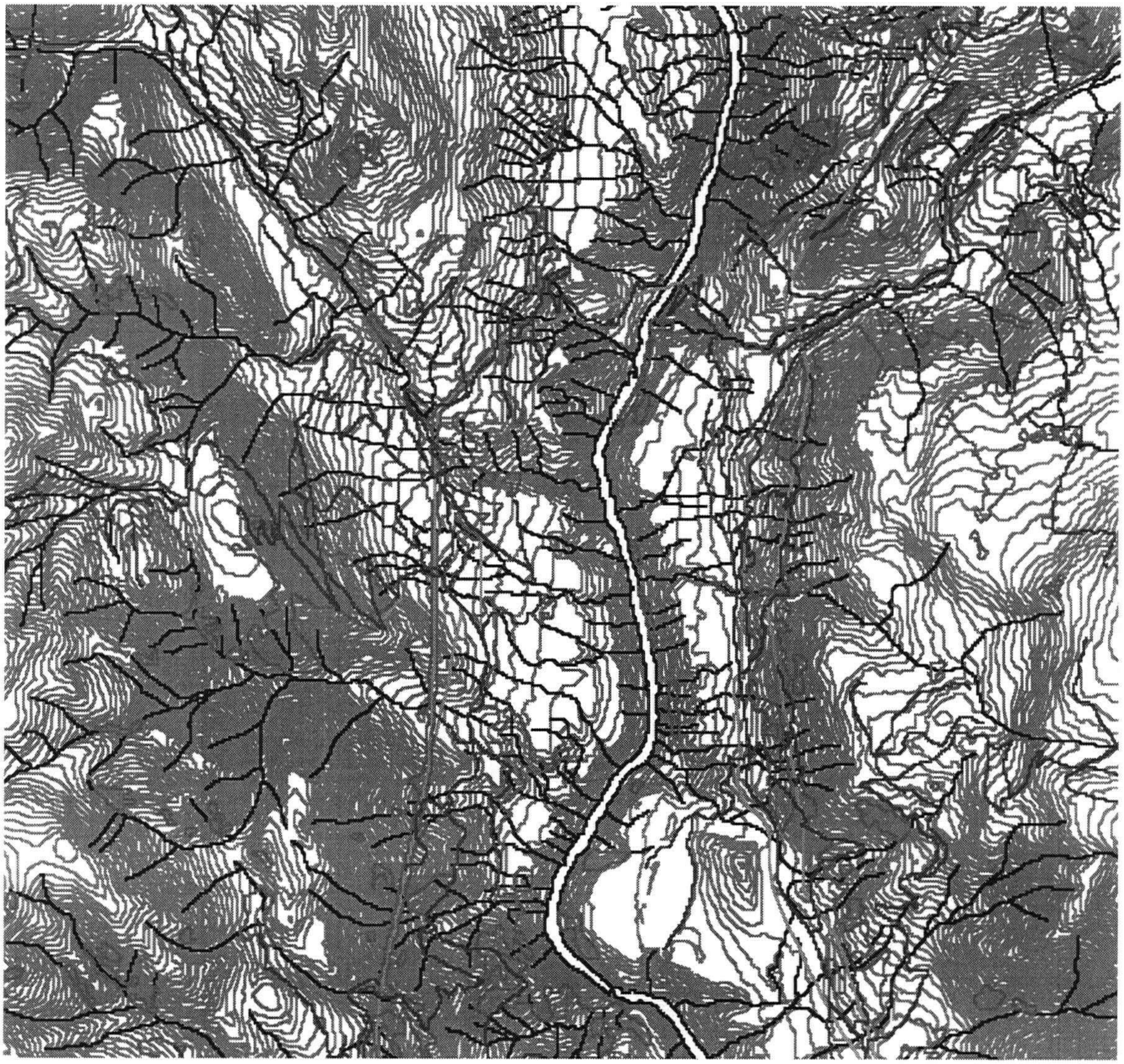


Fig. 4.22 Study area TRIM data in Arcview format

The Archaeology Branch supplied spatial and database information relating to known, recorded archaeological sites in the study area. This information was provided for the purpose of this thesis. All database information present in the database was requested, consistent with the CHIN database recording system. Respecting the classified nature of the information, the records from these database fields are not reproduced here. The database fields are listed in Appendix Two. Point data are shown in Fig 4.23.

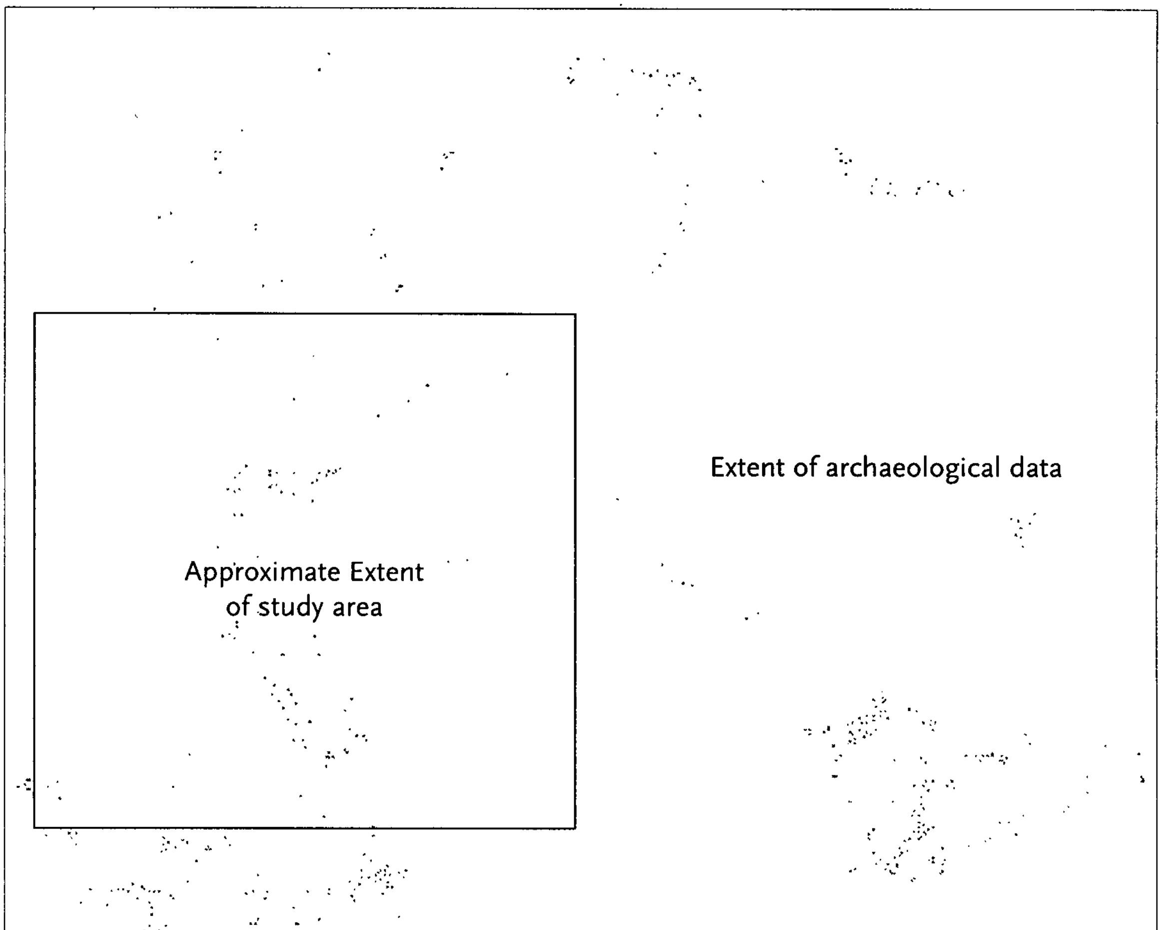


Fig 4.23 Archaeological Point Data

The paper map 92I-13 was purchased from a retailer in Vancouver. This map is at a scale of 1:50,000. This map sheet area corresponds to the archaeological point data. The extents of the study area versus the paper map and the archaeological data are shown in Fig. 4.23.

The remainder of this work concentrates on the elements contained within the smaller area shown above in Fig. 4.23.

Black and white aerial photographs, numbered BC5219-102 to 105 were obtained from Maps BC. These are at an approximate scale of 1:40,000. The photo set follows a north-south flight line along the Fraser River and covers the majority of the study area Fig 4.24.

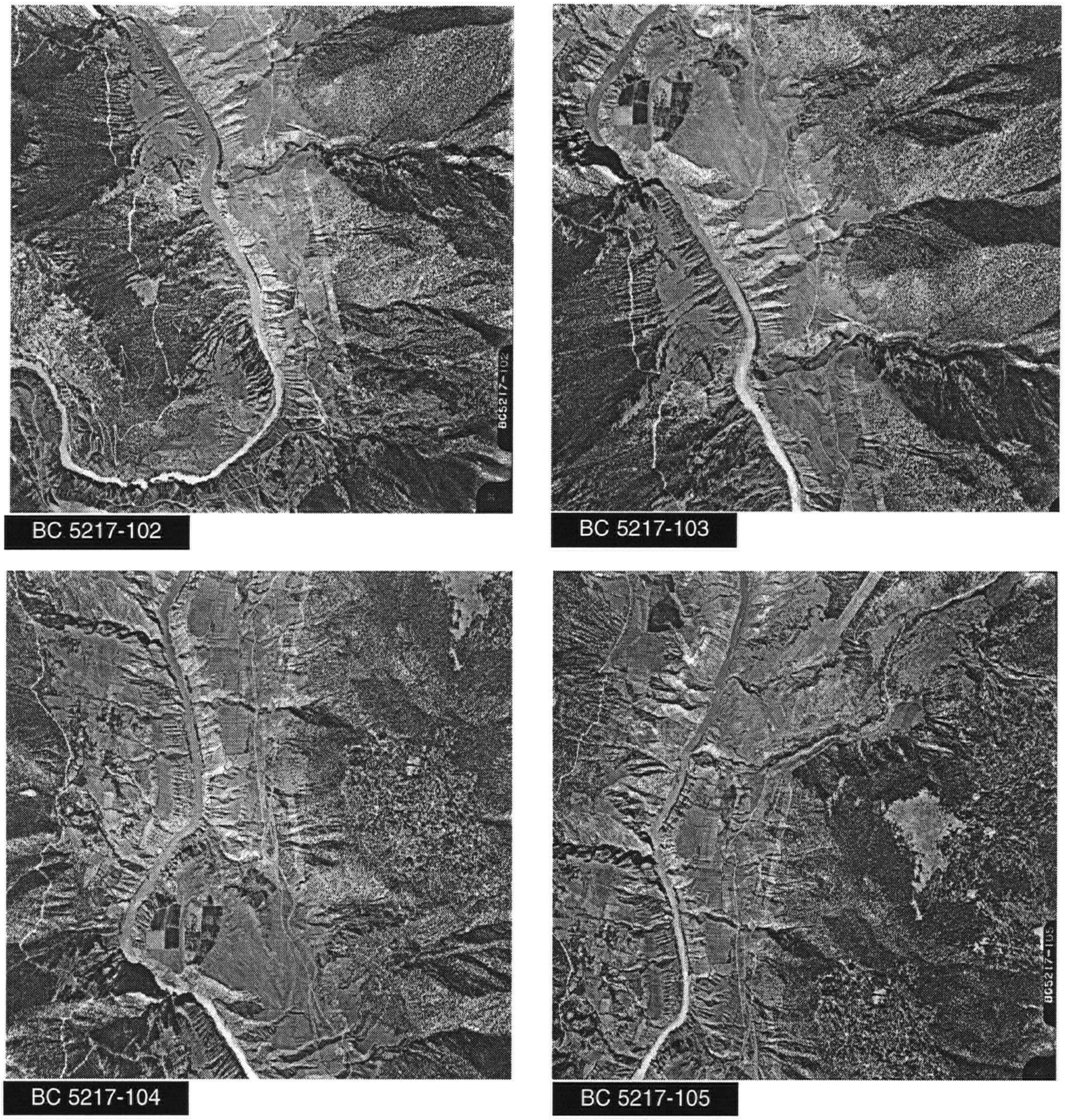


Fig 4.24 Air photograph Coverage of Study Area

The study area is most accurately represented by photos 104 and 105.

An unusual and very interesting aspect of the study area is that it contains the Keatley Creek pit house site. This is one of the most significant pit house sites extant in British Columbia (Hayden, 1992). Important not for artifacts, this site contains in excess of 80 house-pit depressions (my on-site count), many of which are much larger than the typical house pit (Hayden, 1992).

Fig 4.25 Author by Large Pit House Depression, Keatley Creek

Fig 4.26 View over Keatley Creek Site

Photographs of the Keatley Creek site (Fig 4.25 and 4.26) provide an indication of the size, extent, and general location of the pit house depressions. Even cursory examination of aerial photographs shows that the extant physical features are substantial. Prior to a site visit by the author, it was noted during preliminary analysis of the photographs that some pits appeared to be as large as 30 metres. On-ground measurement by the author revealed one large depression (Fig 4.25) with an internal dimension of 24 metres. Mounding and perimeter scatter associated with the pit extends beyond this measurement. The photograph in Fig. 4.26 shows a view across a portion of the Keatley Creek site. The aspect is southwest, and Keatley Creek follows the ravine visible at centre left. Note in both Fig 4.25 and 4.26 the burned trees, remnants of a fire on this site in 1991.

SECTION FIVE

Methods

5.1

General

Fig. 5.21 Study Area TRIM Data Converted to Raster Format

This section describes the general steps performed for this work, and presents the intermediate maps produced. It is not intended to provide a universal 'cookbook' guide

5.2 *Data Conversion*

TRIM data were obtained in an export format of Map Maker Pro, and converted to ArcInfo export files. Following this conversion, the data files were imported into Arcview, and subsequently into MapFactory. The conversion of vector and point data to raster format resulted in working maps with a pixel resolution of 29 metres. This cell resolution was considered acceptable and so no further manipulation was done to change the pixel size. The key database fields identifying each feature were carried over, ensuring that the identity and attribute data of each feature were preserved. The raster data are shown in Fig. 5.21.

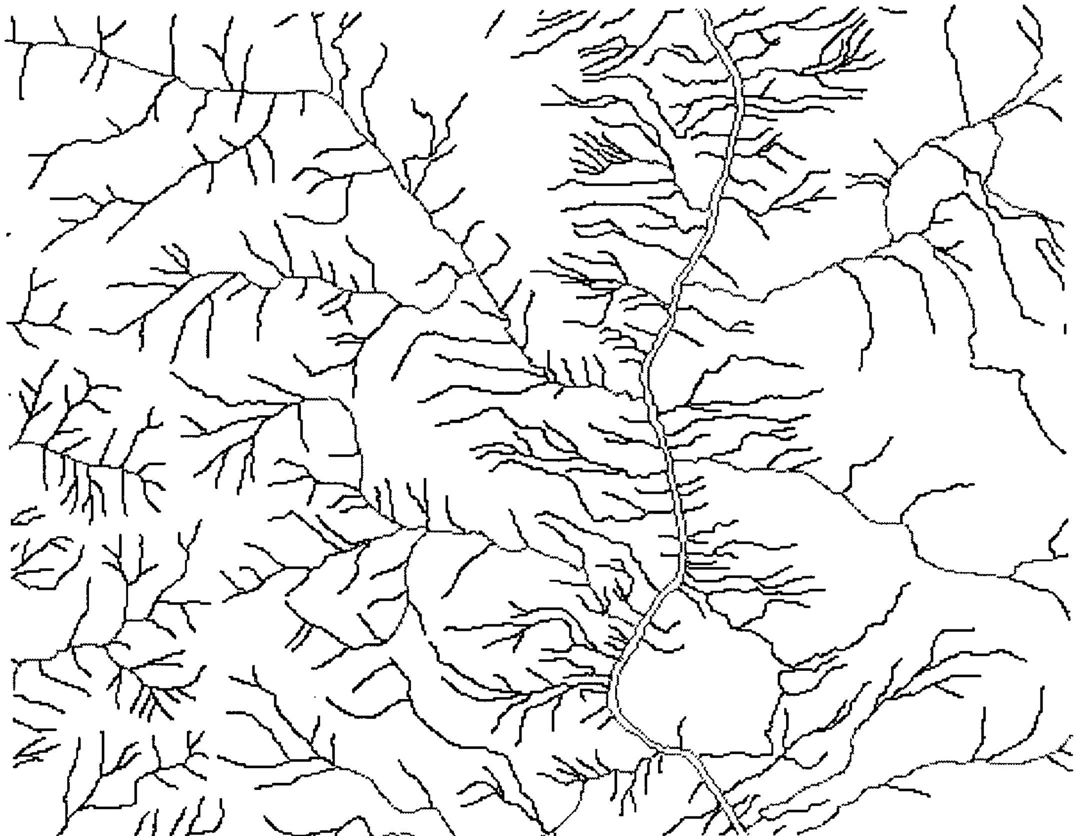


Fig. 5.31 Rivers Divided into Definite and Indefinite Watercourses. Definite Rivers in Blue

5.3 *Procedures*

5.31 Differentiation of River Classes

In the source data, extant watercourses were divided into two classes: definite, with year-round flow, and indefinite, with seasonal flow. Identification of these two watercourse types was taken from the data table associated with the vector-format rivers theme. The translation from vector format preserved the database attribute noting rivers as definite versus indefinite. Using a 'recode' function, a map was produced with two cell values to differentiate between the two river types. Fig 5.31 shows the differentiation of river classes. Definite rivers are blue. Following this operation, buffer zones can be created around the either class of river (see section six).

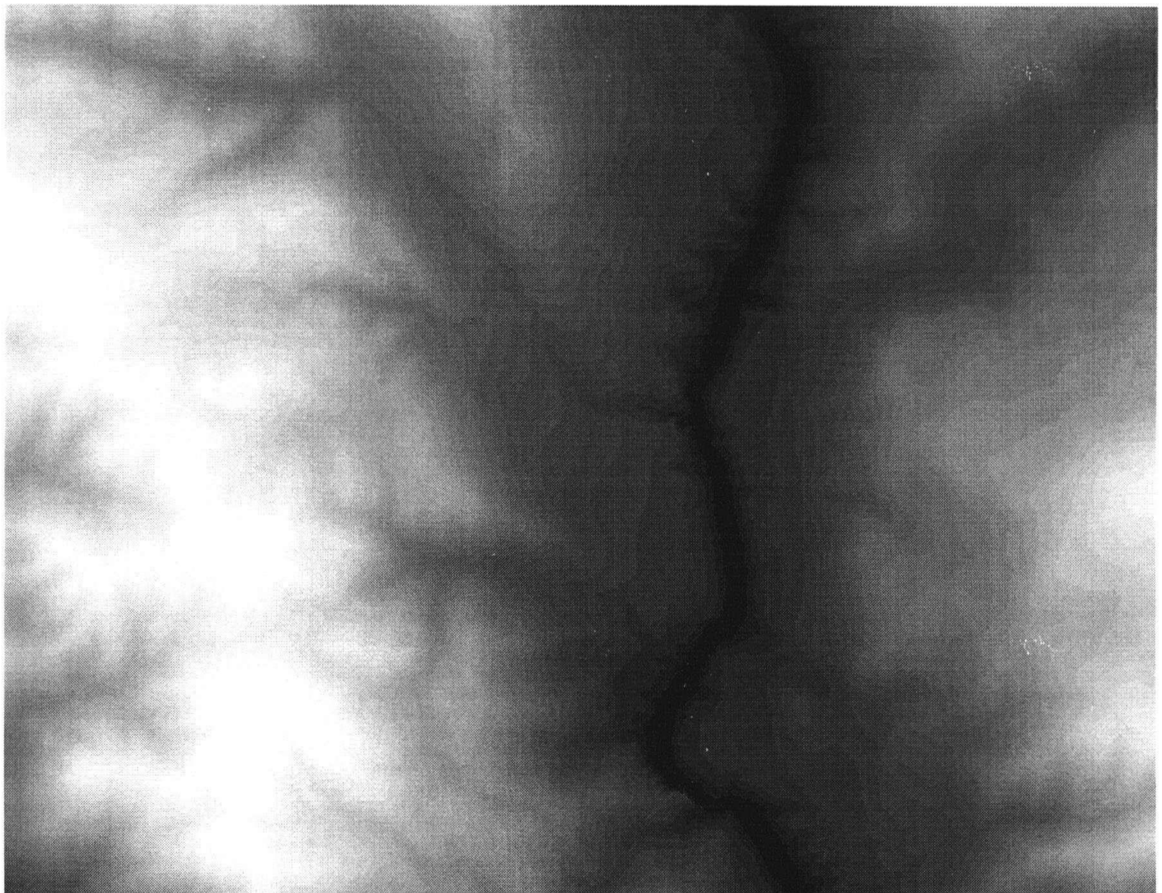


Fig. 5.32 Digital Elevation Model

5.32 Creation of a Digital Elevation Model

Because point elevation data were not available, the contour data were used to create a digital elevation map (DEM) with pixel values representing elevation. The resulting DEM is a raster map with continuous elevation data, and no void (cells with no numerical value) cells. The DEM is shown in Fig. 5.32. Dark pixels represent the lowest elevations, approximately 240 metres, and the Fraser River is apparent as the dark north-south sinuous band. The highest areas are represented by light pixels, with the maximum elevation of 2011 metres in the southwest quadrant of the image.

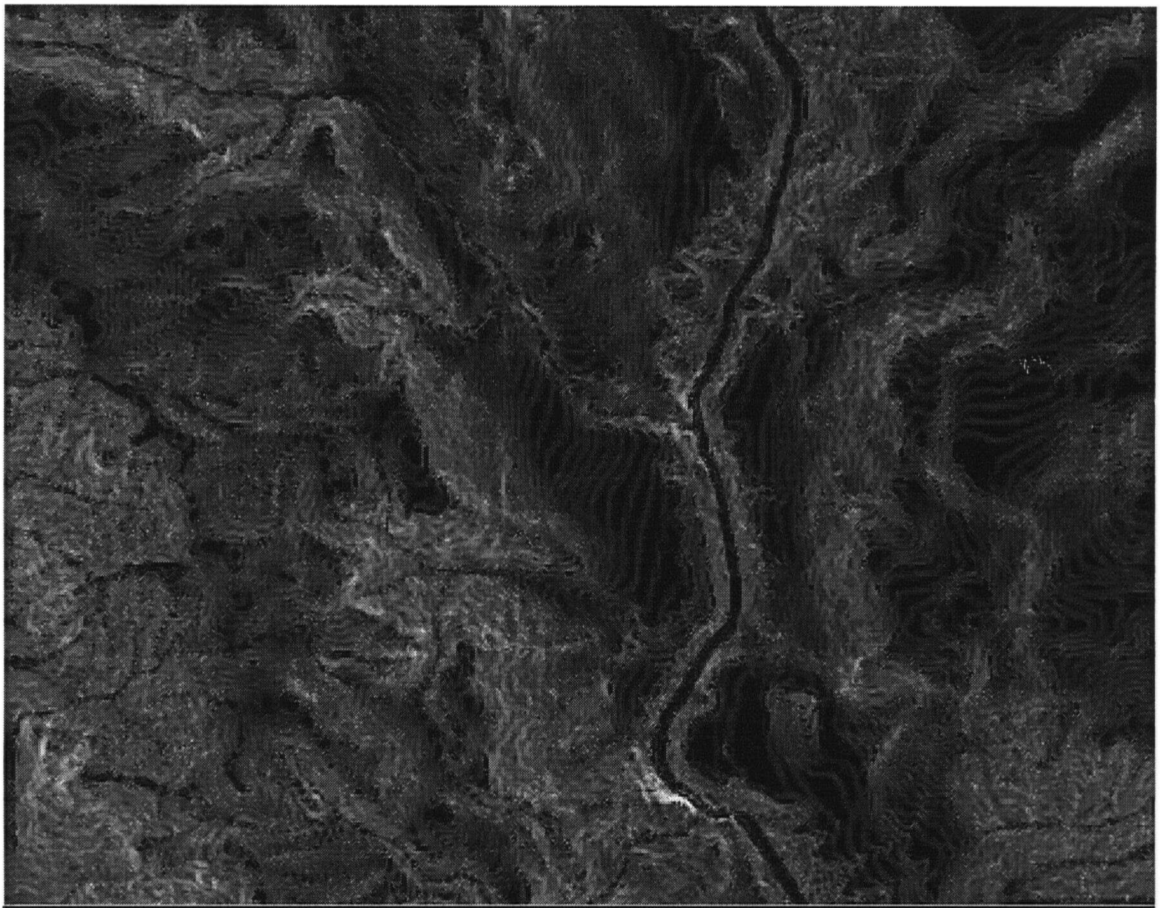


Fig. 5.33 Raw Gradient Map

5.33 Creation of a Raw Gradient Map

Using the DEM, grades in percent were obtained for the study area. The gradient for each cell is determined by an average of six north-south and six east-west slopes surrounding each target cell. The two averages are squared and added together. The square root of the averages is divided by 2 and multiplied by 100 to yield percent slope, based on a quadratic mean. The raw gradient map is shown in Fig 5.33. Gradient pixel values are represented by shades of grey. Dark pixels represent relatively level areas and steep areas are represented by light pixels. The area of very bright pixels, seen most prominently at the curve in the river, lower centre of the image, is a steep rock cliff. The lake bed terraces are seen as broad dark

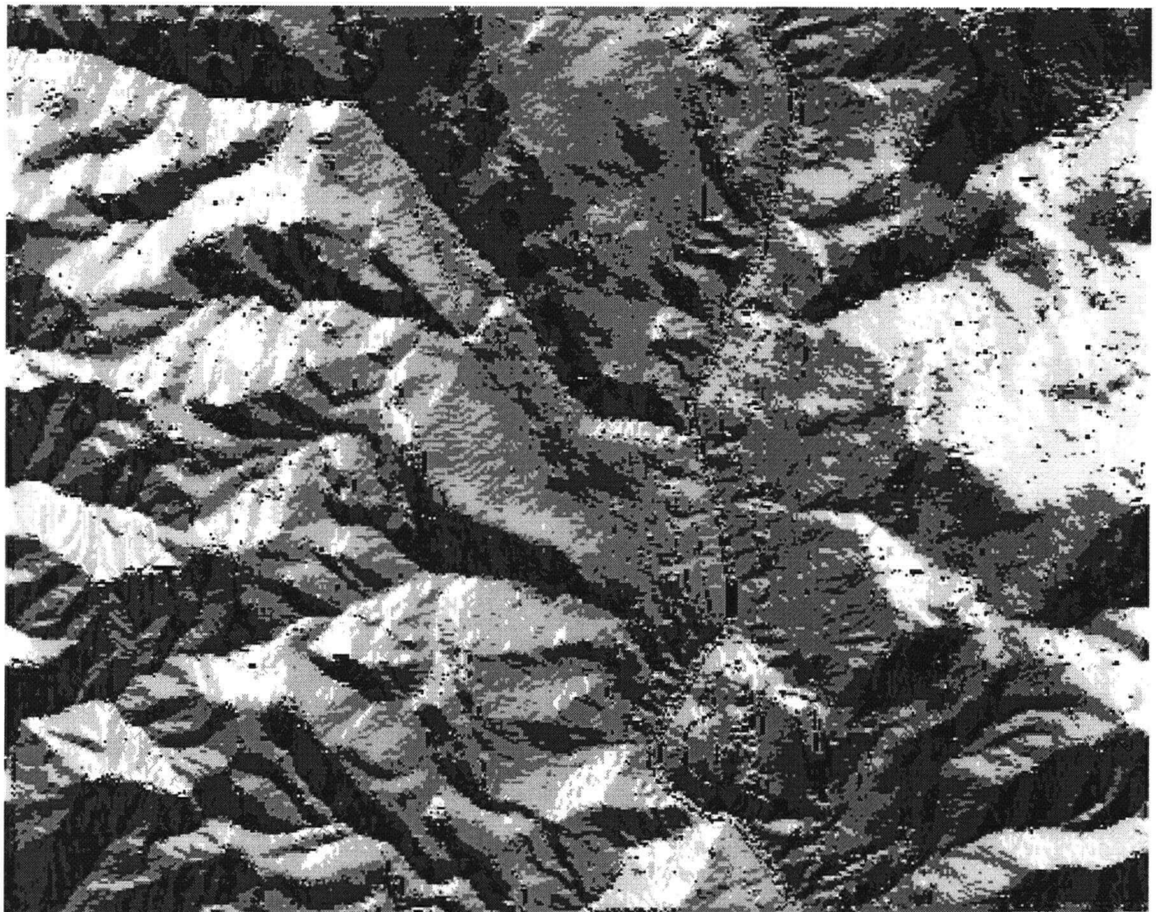


Fig. 5.34 Raw Aspect Map

areas set back from the river. The banding is considered to be distortion in interpolated elevation values due to the use of contours as source data.

5.34 Creation of a Raw Aspect Map

The DEM was analyzed to extract aspect data for the study site. Aspect is ordered into Cardinal aspect classes, Fig. 5.34 This results in eight classes of aspect, each of 45 degrees. North is aspect class 1, northeast is aspect class 2, etc. In Fig. 5.34 above, lighting is from the north. Thus, northeast to northwest aspect slopes are light and southwest through southeast aspect slopes are dark. The degree direction ranges are given in Table 5.35.

Aspect Class		Degree Range
N	1	337.6 - 22.5
NE	2	22.6 - 67.5
E	3	67.6 - 112.5
SE	4	112.6 - 157.5
S	5	157.6 - 202.5
SW	6	202.6 - 247.5
W	7	247.6 - 292.5
NW	8	292.6 - 337.5

Table 5.35
Table of Aspect Classes

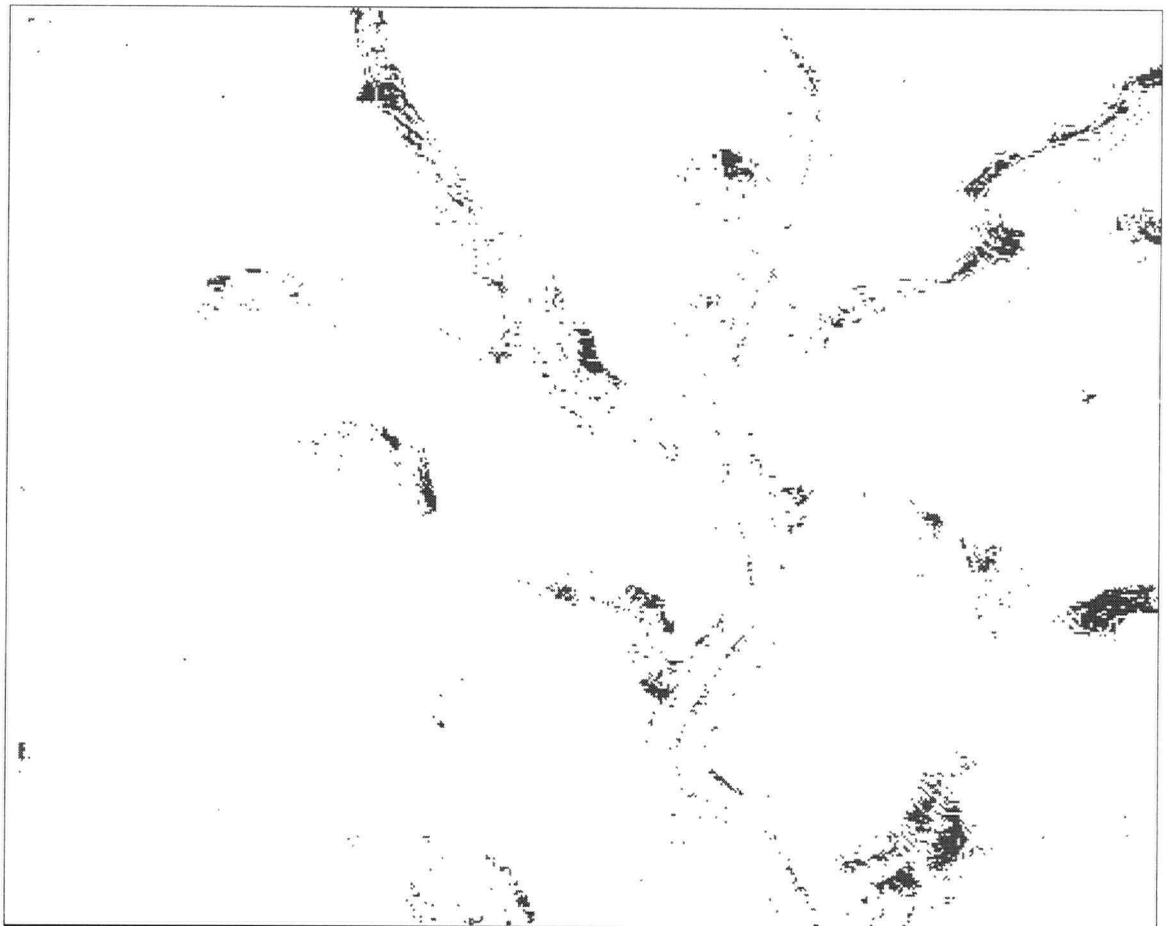


Fig. 5.41 Raw Criteria Intersection Map

5.4 Map Assembly

The model design directed an unweighted Boolean overlay of specific sets of spatial data. The predictive map is the area resulting from the intersection of the refined criteria maps. The following data sets, derived from the base information were superimposed;

- areas of shallow slope, in three classes, to a maximum of 15%
- areas of southeast to southwest aspect
- areas within 350 metres of a definite watercourse

Co-registration of these map layers yielded a map of raw intersection data. Each cell resulting from this intersection satisfies each criteria category. This map is shown in Fig 5.41. The areas indicated in red amount to a total of 340.9 ha, or just over two percent of the study area. Aspect classes for the study area were classified into eight cardinal directions, with southeast (4), south (5), and southwest (6) all proposed as suitable. Slope was classified into four classes; 0-5%, 6-10%, 11-15% (all suitable), and greater than 15% (unsuitable).

Examination of the correspondence between each of the three suitable slopes classes and the range of suitable aspect classes yields three maps which are shown in Figs 5.42 through 5.44. For each of these diagrams, magenta corresponds to aspect class 4, green corresponds to aspect class 5, and yellow corresponds to aspect class 6. Figure 5.45 provides a table listing resulting areas for each of the three slope and aspect classes as seen in figs, 5.42 - 5.44. Areas of suitability based on slope and aspect combinations range from 212.2 ha. to 471.4 ha. These areas were considered

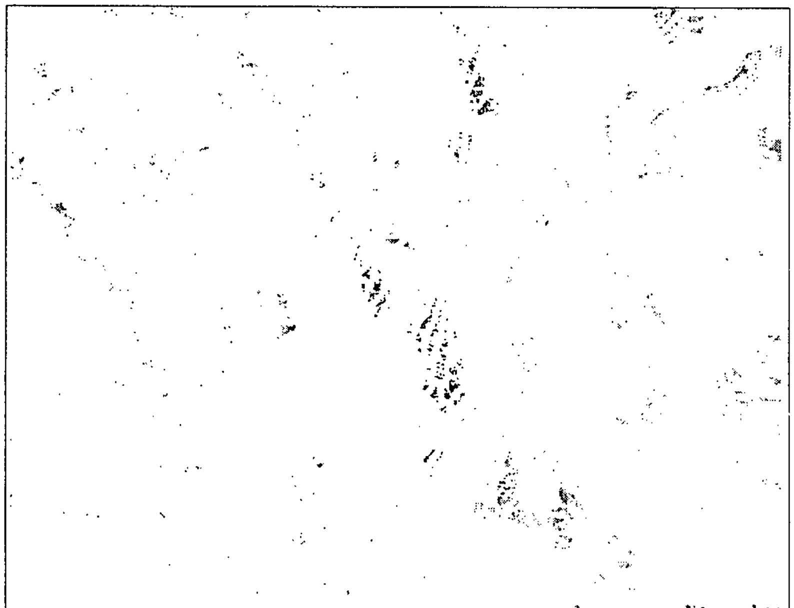


Fig. 5.42 Slopes 0 - 5% and Cardinal Aspect Classes 4, 5 and 6

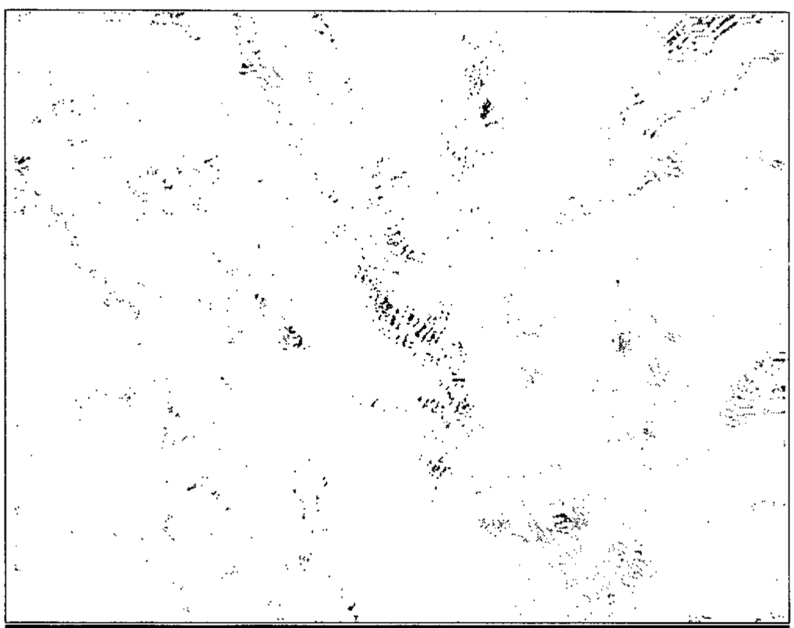


Fig. 5.43 Slopes 6 - 10% and Cardinal Aspect Classes 4, 5 and 6

to be so small in relation to the site area as to be unusable. Reducing further the high potential areas by introducing the buffer around the rivers yields no useful value. Treating slopes as a single range, from 0 to 15% was the logical alternative. Further discussion on this is found in section seven.

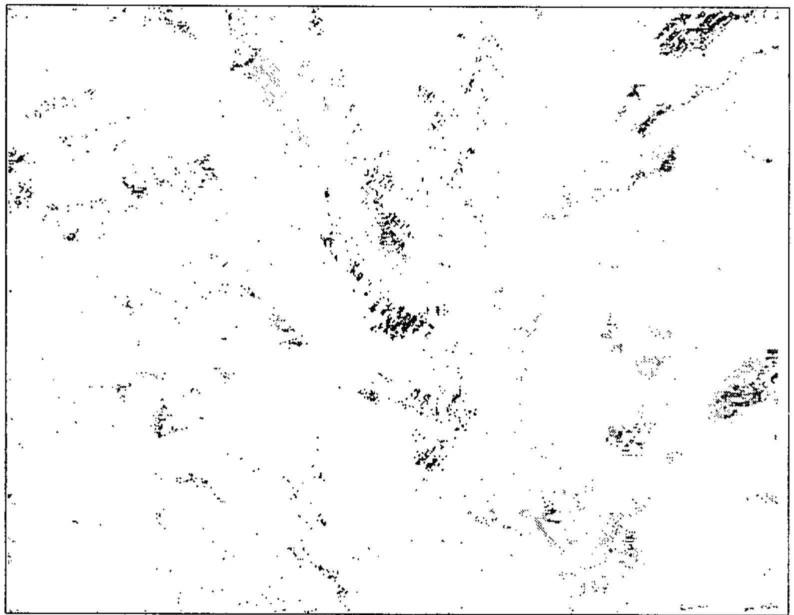


Fig. 5.44 Slopes 11 - 15% and Cardinal Aspect Classes 4, 5 and 6

Aspect Class	Colour	Fig 5.2 0 - 5% slopes	Fig 5.43 6 - 10% slopes	Fig. 5.44 11 - 15% slopes
4 southeast	magenta	83.4 ha	112.7 ha.	173.6 ha.
5 south	green	49.7 ha.	67.9 ha.	121.4 ha.
6 southwest	yellow	79.1 ha.	100.87 ha.	176.4 ha.
Combined areas for suitable aspect classes		212.2 ha.	281.4 ha.	471.4 ha.
Other > 15%	white	15,966.2 ha.	15,897.2 ha	16,178.5 ha

5.5 Landscape Cell Aggregation

To refine the cells resulting from the previous operation into a landscape level spatial pattern, a 130 metre spread was performed, with cells from the map in fig. 5.41 (Raw Criteria Intersection Map) used as target cells. The map resulting from this operation is shown in fig. 5.51. Rather than cells being of interest individually, areas of land, logical for landscape level analysis, are indicated as satisfying the model criteria. Again, this is discussed in section seven.

Grey areas and mauve perimeter band indicate 130 metre spread around areas in Fig. 5.41 Raw Criteria Intersection Map

Fig. 5.51 Refined Criteria Intersection Map

5.6 Final Image Registration

Data sets were overlaid to allow for a graphic analysis of the data and creation of the predictive map. The TRIM data was registered to the archaeological point data using four perimeter points of the TRIM data sheet, in UTM coordinates. In addition, the one known archaeological site location, the Keatley Creek site, was used to verify the alignment of the two data sets. The TRIM data set of spot elevations provided an elevation for this point, allowing for a check of elevation, in addition to easting and northing coordinates. The general coregistration map is shown in Fig. 5.61.

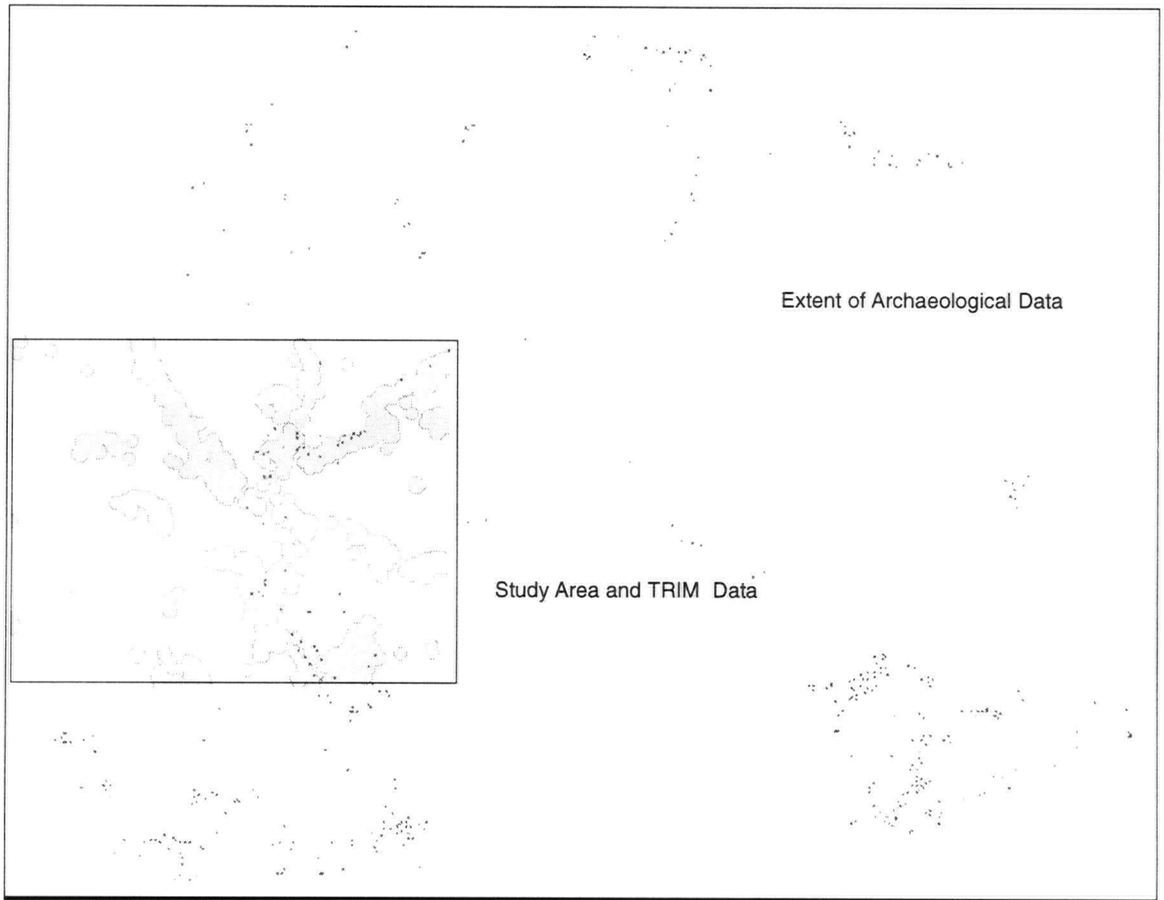


Fig. 5.61 General Coregistration Map

Fig. 5.61 also illustrates the relative extents of the study area in contrast to the archaeological data set area.

Initially the methodology results produced a boolean predictive map. However, two overlapping ranges of predictive areas are produced by the work to this point: the raw intersection data as shown in Fig. 5.41, and the larger area which resulted from the landscape level spread as shown in Fig. 5.51.

5.7 Null Hypothesis Testing- Roads

The sections and map products preceding this section have been developed on the basis of the model proposed in this paper. To provide a null hypothesis test it was suggested that the model methodology be applied using information ostensibly unrelated to historical sites. Road information was selected from the available data sets. Fig. 5.71 illustrates the extant roads within the study area.

Roads	Blue	Paved Surface, One Lane in Each Direction
	Green	Loose Surface, One Lane in Each Direction
	Brown	Loose Surface, Single Track

Fig. 5.71 Study Area Roads

SECTION SIX

RESULTS

6.1

Procedural Results

The maps which result from the processes outlined in section four are presented in this section. They are the results of specific operations dictated by the model design. The general criteria categories used are:

- close proximity to definite water
- areas of gentle slope
- areas of southeast to southwest aspect

My reviews of other models indicates that these criteria are the most widely used, being common to almost all models reviewed. Dalla Bona (1994) illustrates this clearly in his reviews of other work noting another models in which "nine of 15 variables are directly associated with water". Consultation with Lillooet Band member Larry Casper (pers. comm.[9]), provided anecdotal corroboration of these three basic factors. Mr. Casper did consider and agree that these factors are reasonable for the intent of this study.

The intermediate maps following form the building blocks of the model. In producing a final predictive map, the intermediate maps are superimposed. The resulting area of intersection of the criteria forms the core of the predictive map for the study area. A null hypothesis test is also examined. Following the summary of the test, some follow-up examination of the data and results concludes this section.

9. Lillooet Tribal office, Lillooet, 1997

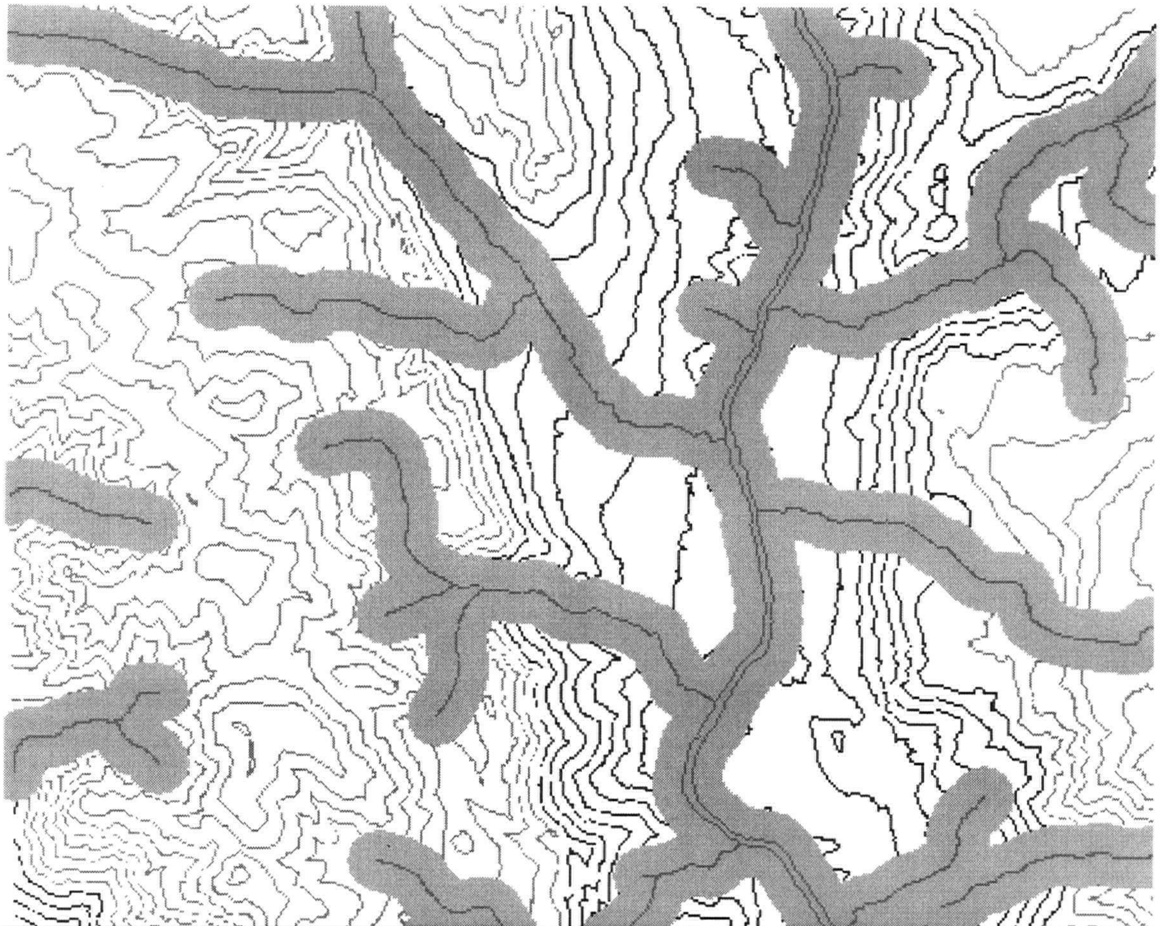


Fig 6.11 Definite Rivers with 700 metre corridor

Rivers

The map showing definite rivers was the source map for a spread operation to create a buffer around watercourses. This buffer is 700 metres wide, extending 350 metres to each side of each definite watercourse. Although 350 metres is not a multiple of the 29 metre pixel resolution, the software evaluates distance in Euclidian fashion from cell centre to cell centre. Resulting cell values indicate the actual distance, and are not constrained by the cell resolution. Fig. 6.11 gives the result of this operation. The buffer width is based on anecdotal information from Lillooet Band members (noted elsewhere). Differentiation between definite and indefinite watercourses is an adoption of a criteria filter from Dalla Bona (1994).

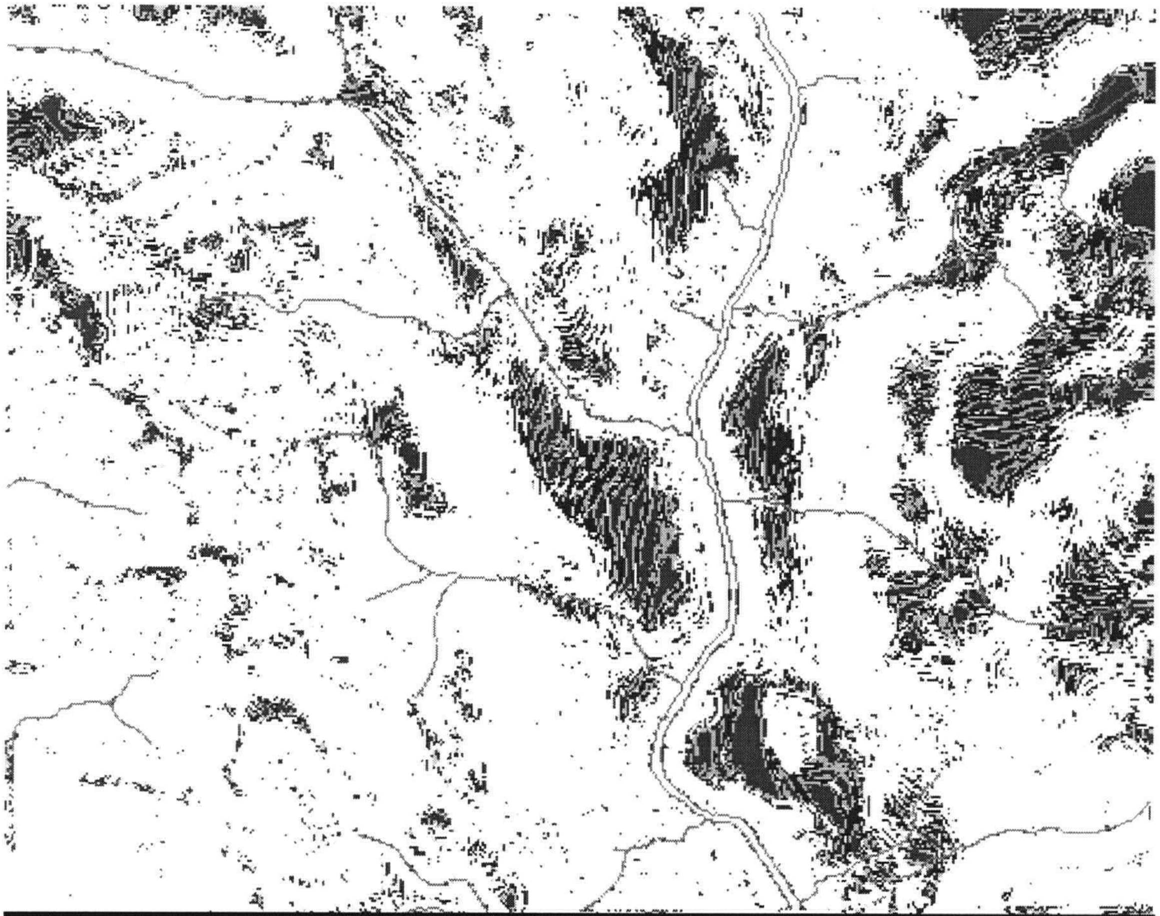


Fig. 6.12 Selected Slope Classes

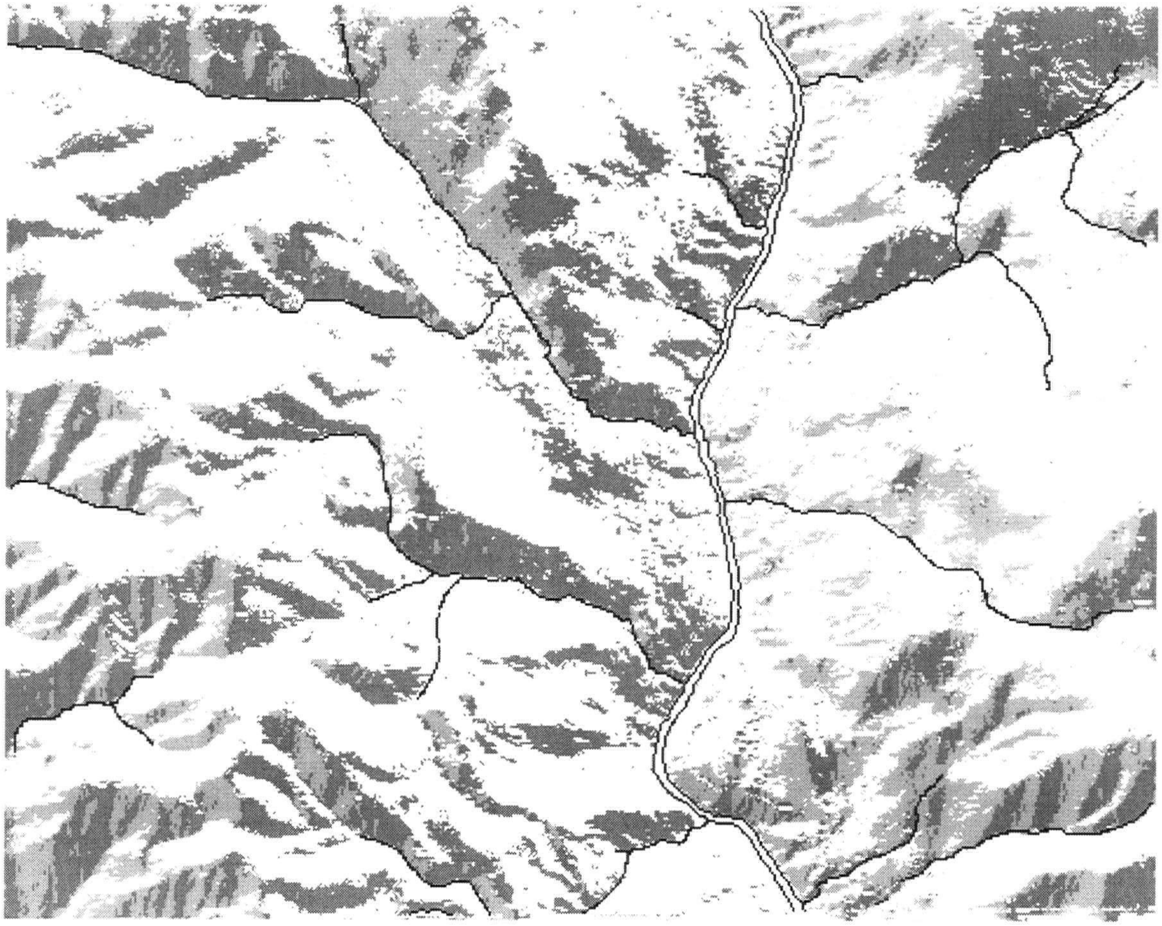
Colour	Slope Class	Area Within Class	Percent of Total Area	
Red	0-5%	1033.5 ha.	6.4%	Suitable
Green	6-10%	798.1 ha.	4.9%	Suitable
Blue	11-15%	1423.3 ha.	8.8%	Suitable
White	>15%	12923.5 ha.	79.9%	Unsuitable

Fig. 6.13 Breakdown of slope classes

Although these distances do correspond with modeling distances used by others (Eldridge et. al, 1993, Scott, 1994, Muir et. al, 1994), this is the least reliable of information used in this work.

Slope

The raw gradient map was recoded to extract and display only portions of the study area in each of four specific slope classes. This map of slope classes is shown in Fig 6.12. The slope classes and the areas within each slope class are given in Fig. 6.13.



Colour	Aspect Class	Area Within Class	Percent of Total Area	
Magenta	Southeast	1865.7 ha.	15.8 %	Suitable
Green	South	1476.2 ha.	9.1 %	Suitable
Yellow	Southwest	2159.3 ha.	13.6 %	Suitable
White	Other	10637.1 ha.	65.8 %	Unsuitable

Fig.6.14 Selected Aspect Classes

Aspect

Aspect information was derived from the DEM. Aspect was computed as cardinal direction rather than in degrees. The map of suitable aspect areas is shown in Fig 6.14. Fig. 6.15 gives the table of aspect classes for the specific aspect ranges.

Aspect Class		Degree Range
N	1	337.6 - 22.5
NE	2	22.6 - 67.5
E	3	67.6 - 112.5
SE	4	112.6 - 157.5
S	5	157.6 - 202.5
SW	6	202.6 - 247.5
W	7	247.6 - 292.5
NW	8	292.6 - 337.5

Fig. 6.15
Breakdown of Aspect Classes

6.2 Final Predictive Map

Originally intended as a boolean indicator map, section five methods yielded two maps which are combined to create a three step predictive map. The Raw Criteria Intersection Map, Fig. 5.41 and Fig. 6.21 below, is now considered as the 'red flag', or high potential zone. Around this, the 130 metre buffer zone originally proposed as the archaeological zone becomes a second level zone of moderate potential. This area is shown in Fig. 6.22. The remainder of the study area is assigned a low potential rating.

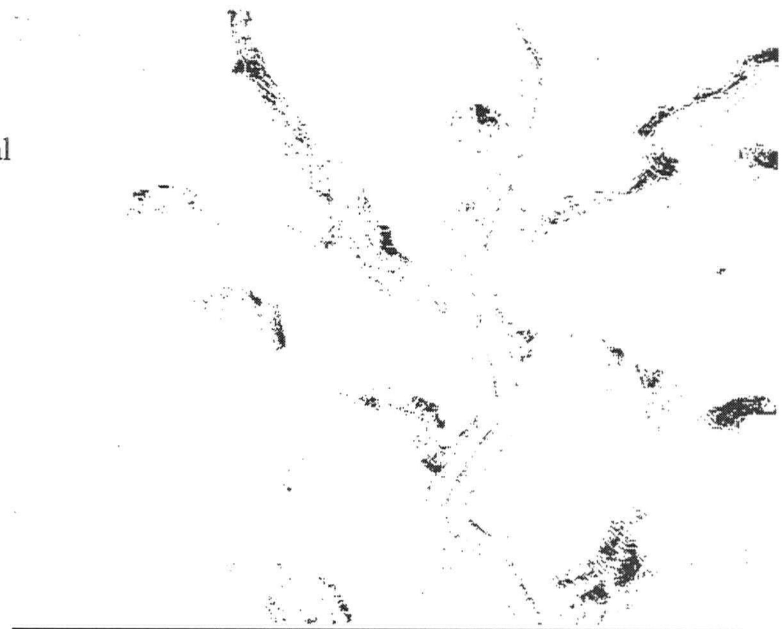
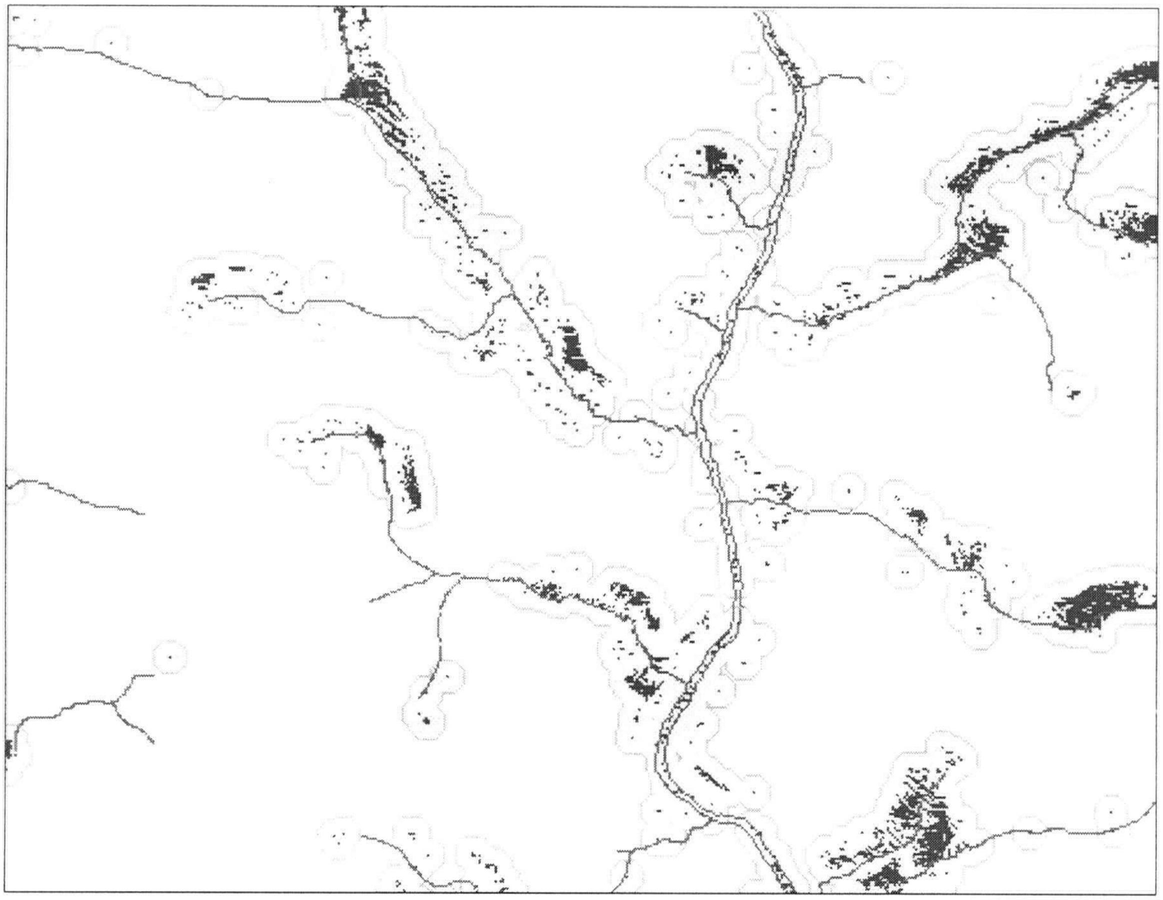


Fig. 6.21 High Potential Areas

Fig. 6.23 following shows the map produced by the union of the maps in Figs. 6.21 and 6.22. Areas covered by red pixels or within the yellow polygons are proposed as having a elevated potential of containing sites of heritage value.

Fig. 6.22 Moderate Potential Areas



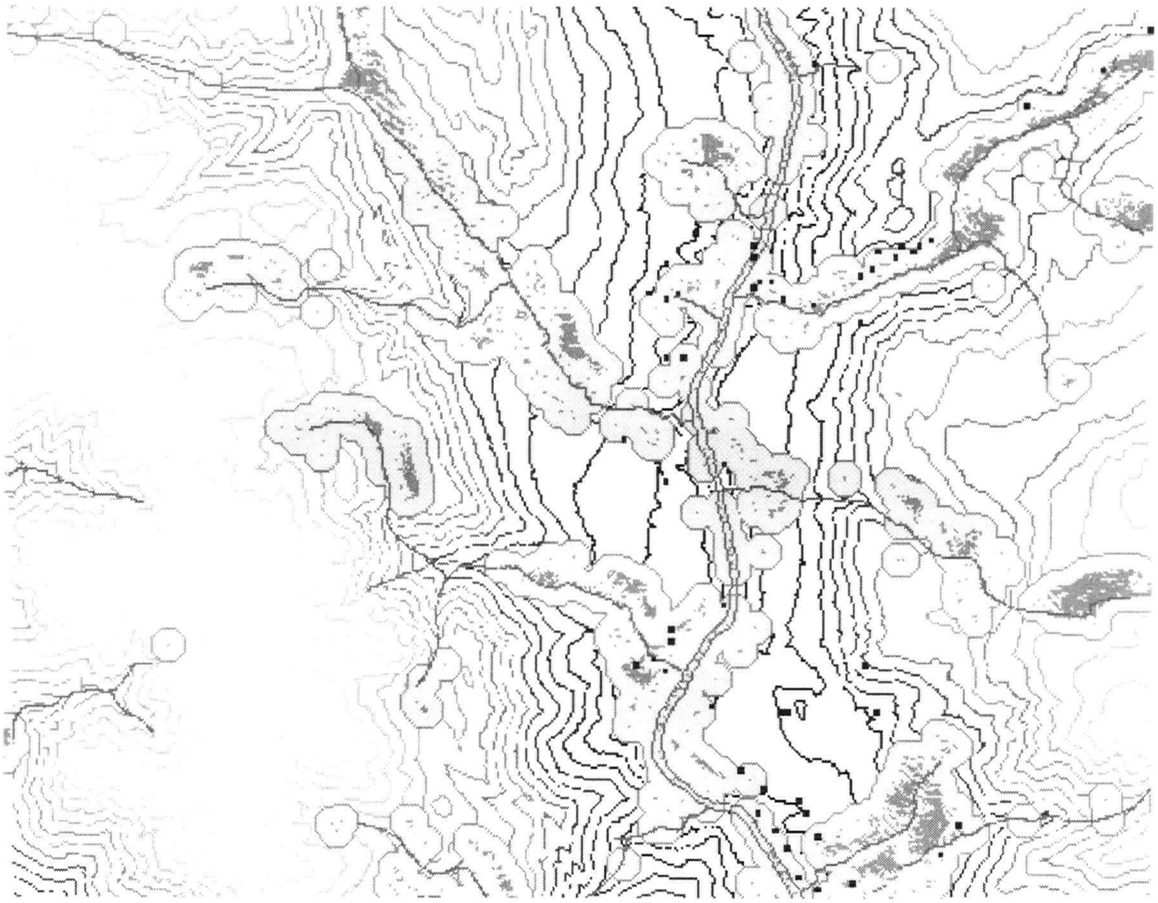
Olive Green	High Potential Zone
Yellow and Orange Boundary	Moderate Potential Zone
Purple	Definite Rivers

Fig. 6.23 Final Predictive Map

This map represents areas which satisfy each of the criteria proposed in the model development.

6.3 Testing of Predictive Map

Figure 6.31 displays the overlay of the model proposal map and the recorded archaeological data. Areas proposed as high and moderate potential for heritage sites are evaluated against the known, recorded heritage sites. This is the essential evaluation step in this process. Visually, it appears that many of the known heritage sites coincide with the area of proposed



Red	Recorded Archaeological Sites
Olive Green	High Potential Zone
Yellow and Orange Boundary	Secondary Potential Zone
Purple	Definite Rivers

Fig. 6.31 Model Testing Map

high and moderate potential for heritage value. Clearly, many sites also fall outside the area predicted as having archaeological potential. Note that the high and moderate potential zones are based on two types of information. The high potential area is derived directly from the manipulation of map data. Any individual 29 metre square pixel may be indicated. The moderate potential zone is judgmental, the 130 metre buffer around the raw criteria intersection areas resulting in a larger areas which generally eliminate individual pixels from appearing alone. More complete understanding of Fig. 6.31 comes with further evaluation of the results and criteria. This discussion follows here in Section Six and in Section Seven as well. Fig. 6.41 presents the results of this test in a summary table.

6.4 Model Results

The archaeological data map, at a scale of 1:50,000 depicts an area of approximately 1,011 square kilometres (101,092 ha.). The number of recorded sites within this map sheet is currently 456 sites. The study area covers approximately 161 square kilometres (16,146 ha.), and contains 58 recorded archaeological sites. The data for the test area are corrected by reducing the number of known sites and the total of successfully predicted sites by one each. This is to exclude the Keatley Creek site, the location of which was known prior to executing this work. With this adjustment, the predictive map produced:

- identified 3,689 hectares as being of high or moderate archaeological potential.
- contains 42 of the 57 recorded sites in the study area.

This represents 73.4% of the known recorded sites in the study area.

If the Keatley Creek site is not removed from the calculation, the high and moderate potential zones together contain 43 of 58 sites. This is 74.1 % of the known, recorded sites.

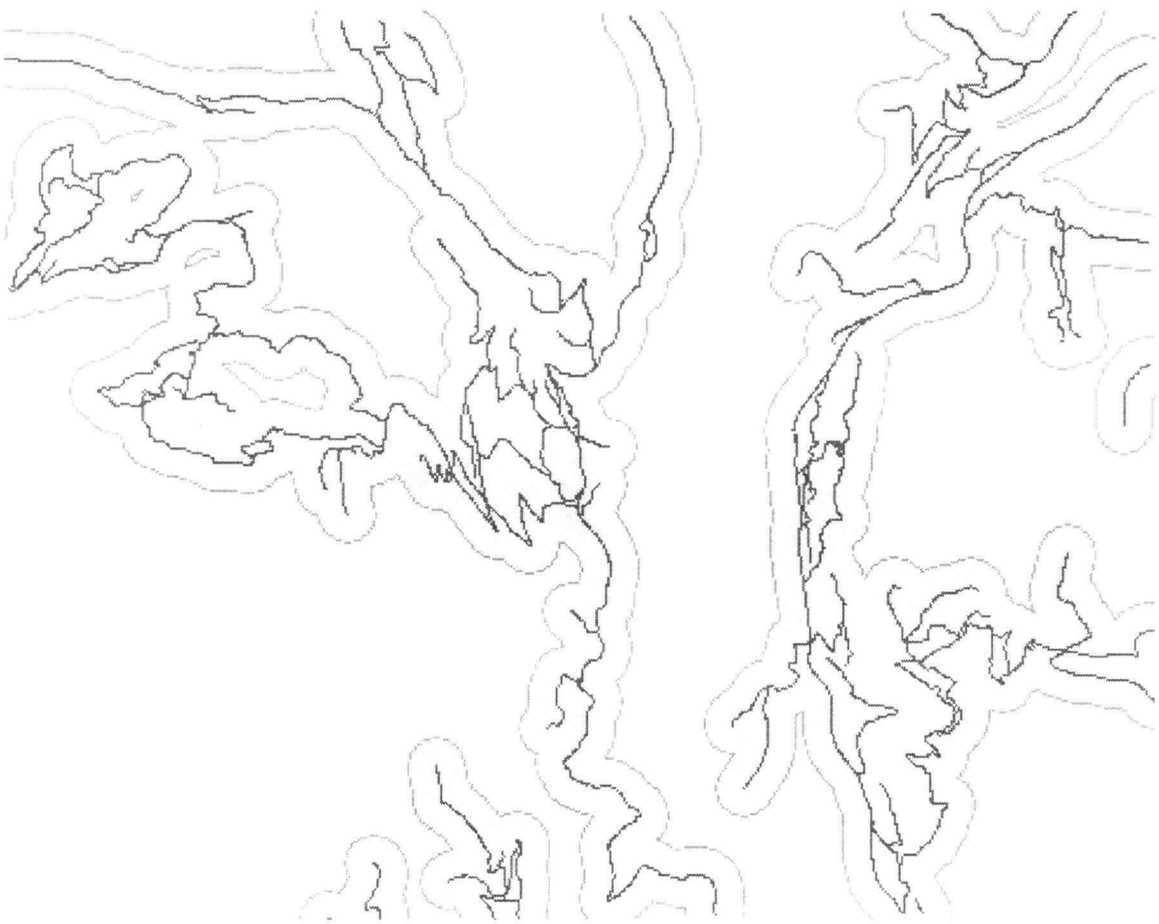
The summary of results is expanded in table 6.41 following.

Land Area	
Total land within the study area:	16,146 ha.
Area identified as high potential:	340.9 ha.
Area identified as moderate potential (n.i.c high potential area):	3,348.1 ha.
Percentage of land denoted as high potential:	2.1%.
Percentage of land denoted as moderate potential:	20.7%
Total area in high and moderate potential zones:	3689.0 ha.
Percentage of land in high and moderate potential zones:	22.8%
Sites Recorded and Predicted	
Total number of recorded sites present in study area:	57
Number of recorded sites within high potential zone:	5
Percentage of recorded sites within high probability zone:	8.8%
Number of recorded sites in moderate potential zone	37
Percentage of recorded sites within moderate probability zone:	64.9%
Number of recorded sites within combined probability zones:	42
Percentage of recorded sites within combined probability zones:	73.7%
Percentage of recorded sites within combined probability zones including known site - 43/58	74.1%

Table 6.41 Table of Model Results

6.5 Null Hypothesis Testing Analysis

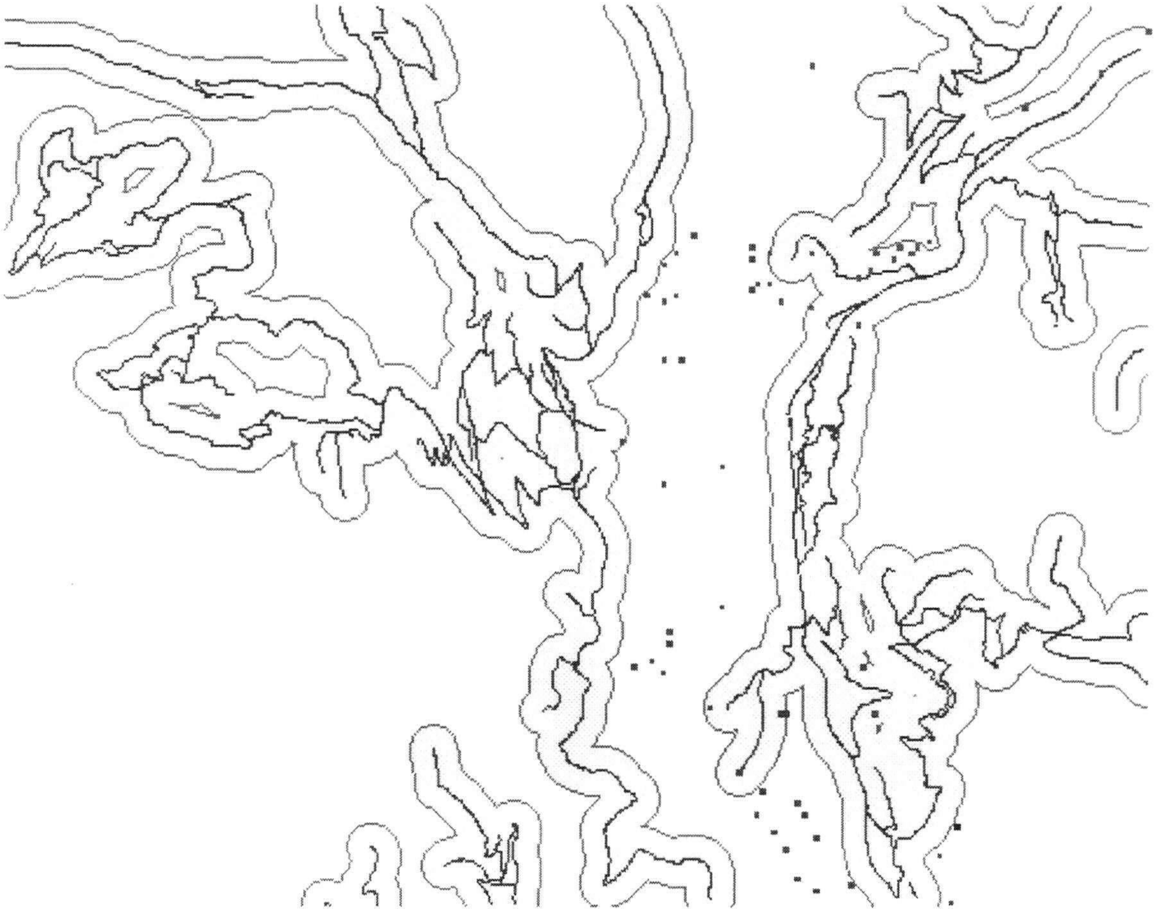
Following the comparison testing between the high and moderate predictive zones with the recorded site data, the null hypothesis test was performed. Ostensibly the locations of roads and the locations of heritage or archaeological sites are not related. To examine the possibility of coincident locations, the 350 metre buffer applied to rivers was applied to all roads in the study area. This is seen in Fig.. 6.51 below.



Brown — Roads
Grey and Blue Perimeter — 350 Metre Buffer Zone

Fig. 6.51 **Null Hypothesis Predictive Map**

Over this null hypothesis predictive map, the recorded site data were superimposed to provide a test of the predictive power of roads. The mapping results of this test are seen in Fig. 6.52 following. The summary of the results of this test are given in table 6.53 below:



Green Squares	Recorded Archaeological Sites
Red Squares	Keatley Creek Site
Brown	Roads
Grey and Red Boundary	350 Metre Buffer Zone

Fig. 6.52 Null Hypothesis Testing Map

Land Area

Total land within the study area:	16,146 ha.
Area identified as high potential:	6871.7 ha.
Percentage of land denoted as high potential:	42.6%.

Sites Recorded and Predicted

Total number of recorded sites present in study area:	58
Number of recorded sites in high potential area:	19
Percentage of recorded sites within high potential area:	32.8 %

Fig 6.53 Null Hypothesis Results Summary

6.6 Post Testing Data Assessment

Following the development and testing of the original model, a secondary examination of the archaeological data was carried out. As noted earlier, the predictive model presented thus far is blind; no foreknowledge of the extent or layout of the archaeological resource existed which would prejudice the model; the Keatley Creek site was excluded from the evaluation. With the overlay of the predictive map onto the archaeological data, further examination of the archaeological data is appropriate and possible. This examination consisted of judgmental evaluation of characteristics of the archaeological sites within the study area, examination of cutoff values of the modeling criteria used, and basic graphing of the distributions of values obtained.

The 58 sites within the study area are listed in the table following, Fig. 6.61. The first column of the data table shows site identification numbers. These site numbers are consistent with the numbering system assigned in the CHIN database. The next three columns give the corresponding values for slope, aspect, proximity to water. The fifth column gives a description of each site based upon my interpretation of the geographical data of the study area.

The values in Fig. 6.61 are derived from the raster maps for each variable. The descriptive notes in the fifth column are added observations of the recorded sites locations. These are my observations and are based on judgmental interpretations of the data. The absence of even this brief level of descriptive data in the CHIN database precludes any interpretative conclusions based on non-numeric characteristics, using the CHIN data. Presumably, the information derived here could be included in the CHIN database if such fields exist, or are deemed desirable.

Site	Slope	Aspect	Dist to Water	Location Note
68	29%	5	475metres	E. Pavilion
69	29	7	0	River Edge
70	1	4	29	E. Pavilion
71	18	4	211	E. Pavilion
72	10	4	533	Rvr. Trce Edg
73	34	3	551	Rvr. Trce Edg
74	8	3	0	River Edge
75	32	4	221	
76	32	5	232	Pavilion
77	50	5	246	Pavilion
78	24	7	563	Inland High
79	52	8	41	River Edge
80	2	4	0	River Edge
81	28	5	174	Pavilion
82	31	5	290	Pavilion
83	13	5	410	
84	28	5	148	Pavilion
85	19	4	120	Pavilion
86	19	5	116	Pavilion
87	10	8	91	River Edge
88	13	7	186	
89	0	4	0	River Edge
90	28	3	261	
91	27	6	29	River Edge
92	34	2	58	
93	32	7	0	River Edge
94	10	6	58	
95	28	8	95	
96	39	2	350	Rvr. Trce Edg
97	22	3	164	River Edge
99	3	3	319	Inland•
104	30	7	58	River Edge
106	6	2	529	Rvr. Trce Edg
116	38	3	29	River Edge
117	12	4	274	Rvr. Trce Edg
118	13	4	176	Rvr. Trce Edg
119	7	3	0	Rvr. Trce Edg
121	4	4	105	Rvr. Trce Edg
122	23	2	41	Rvr. Trce Edg
124	29	6	1456	Inland
125	7	8	312	Rvr. Trce Edg
126	25	7	1164	Knob Feature
127	15	7	944	Inland
128	1	6	321	Rvr. Trce Edg
129	6	6	267	Rvr. Trce Edg
130	6	6	532	Rvr. Trce Edg
131	27	6	29	River Edge
132	16	7	547	Rvr. Trce Edg
133	37	6	82	River Edge
134	11	6	58	Inland
135	9	8	303	Rvr. Trce Edg
136	9	7	92	River Edge
137	6	7	58	Inland
138	25	6	29	River Edge
141	9	6	205	Rvr. Trce Edg
143	27	7	29	River Edge
145	35	7	620	Inland
452	25	7	1234	Knob Feature

Key to Fields

Site: Site number as per CHIN database

Slope: Gradient in percent

Aspect: Aspect in cardinal classes

Distance to Water: Distance in metres to nearest definite rivers

Location Note: Interpretative notes for each recorded site location

Location Note Key

Pavilion
Sites which fall within the general area of the present day Pavilion Indian Reserve lands

E. Pavilion
Sites east of the Pavilion IR, closer to Pavilion Lake

Rvr.Trce. Edge
Sites which are situated on the edge of river terraces or lake bed terraces overlooking the Fraser River

River Edge
Sites at rivers edge, below terraces

Inland
Sites of higher elevation, and isolated from other sites

Knob
Sites on or adjacent to the large, basaltic rock hill at lower centre right of study area.

Fig 6.61 Values for archaeological site locations derived from raster map of study area

In summary, the criteria ranges are given in Fig. 6.62. Histograms of the criteria values for each site pixel follow in Fig's. 6.63 - 6.64. These provide a visual representation of the data. The values in these histograms are taken from the site chart in Fig. 6.62.

Slope		
	Range High	52
	Range Low	0
Aspect		
	Range High	8
	Range Low	2
Distance to Water		
	Range High	1456
	Range Low	0

Fig 6.62 Basic Summary for Archaeological Site Locations

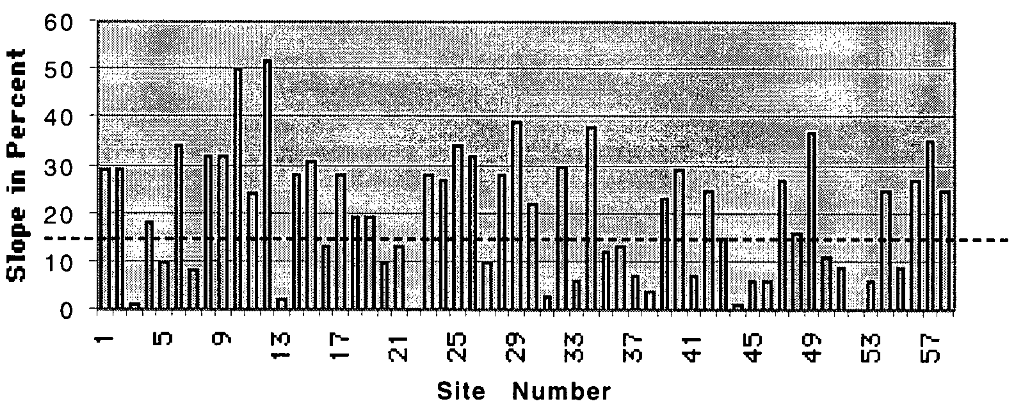


Fig 6.63 Slope Values Distribution

The model cutoff value of 15% is indicated by the dashed line in Fig. 6.63. 24 of 58 extant sites fall within the slope range of 0 - 15%. This is 41.3% of the study area sites. 34 or 58.6% of sites are outside the selected slope value cutoff.

Fig. 6.64 following displays the slope data in a cumulative distribution plot. The results of the combined predictive areas is 74.1 % of extant sites. Based on the slope values present, a cutoff value of 29% would be necessary to achieve the same result. However, as Fig. 6.64 shows, a cutoff of 29% would in fact return 45, or 77.6% sites, as three sites have slope

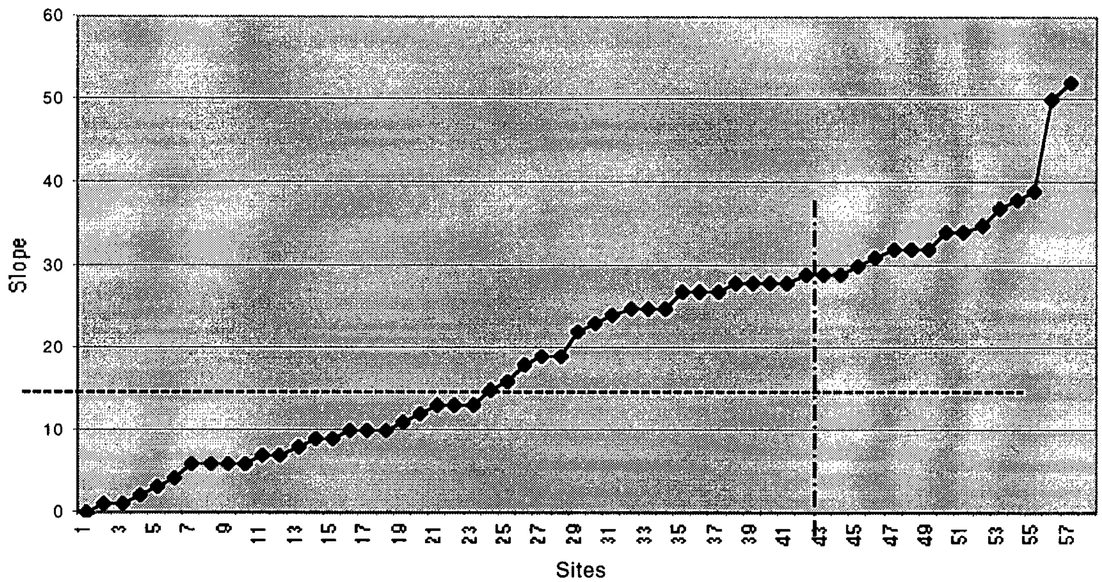


Fig 6.64 Cumulative Slope Values

values of 29%. The 15% cutoff value for slope is indicated by the horizontal dashed line. A vertical dot - dash line at 43 represents 74.1% of sites .

Recorded aspect values range from two to eight. Fig. 6.65 below shows the aspect class distribution. Fig 6.66 following defines the ranges of each aspect class.

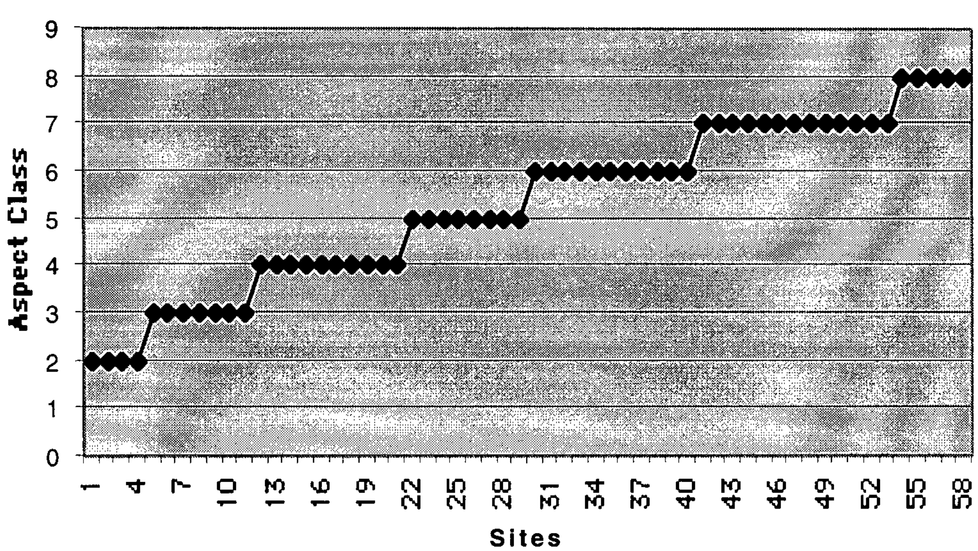
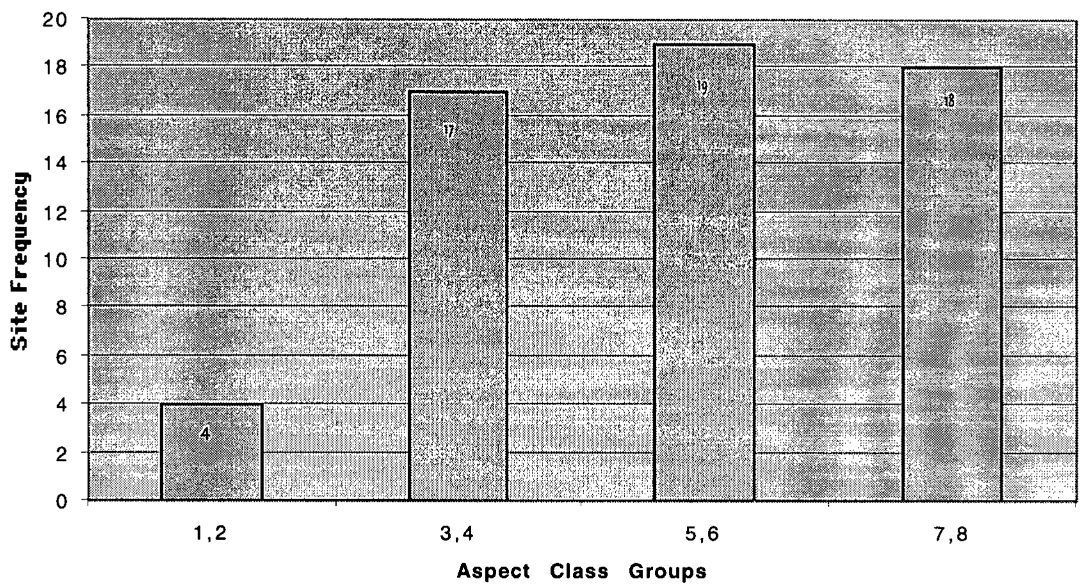


Fig 6.65 Cumulative Aspect Values

The aspect distribution becomes more interesting (to me) if the eight cardinal classes are re-grouped into four classes. There are no recorded sites in aspect class 1, four in class two and five in class eight.. Fig. 6.67 below groups classes 1 and 2, three and four, five and six, and seven and eight. Site frequency is shown as well.

Aspect Class		Degree Range
N	1	337.6 - 22.5
NE	2	22.6 - 67.5
E	3	67.6 - 112.5
SE	4	112.6 - 157.5
S	5	157.6 - 202.5
SW	6	202.6 - 247.5
W	7	247.6 - 292.5
NW	8	292.6 - 337.5

Fig 6.66 Aspect Class Ranges



Aspect Class Group	Site Frequency
1 and 2	0 +4
3 and 4	7 + 10
5 and 6	8 + 11
7 and 8	13 + 5

Fig 6.67 Grouped Aspect Values

The model proposed aspect classes 4, 5 and 6 for predictive ability. Of the 58 recorded sites present, 29 are in those ranges of aspect. This is 50%. Aspect class 7 does, however, contain 13 sites, more than any other single class. Dividing the eight initial classes into two groups would allow for classes 4 - 7 to reveal 42, sites(72.4%), as opposed to classes 1 - 3,8, which would reveal 16 (27.6%) sites.

The results for distance to water values cover a broad range, from (effectively) zero to in excess of 1400 metres. The mean of these values is 266.64 and the standard deviation is 313.89. Fig. 6.68 below shows the distribution of values.

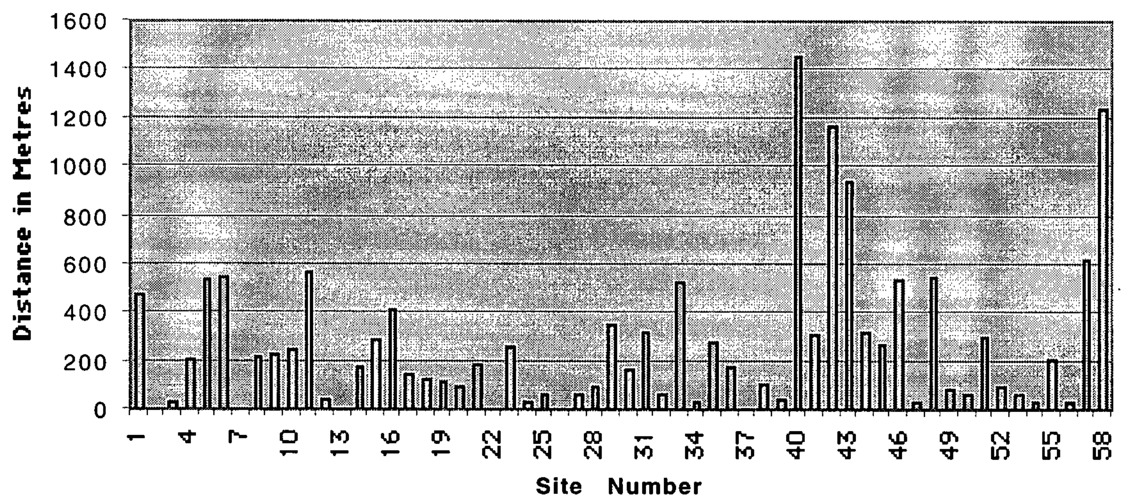


Fig 6.68 Distance to Water Values Distribution

SECTION SEVEN

Discussion

7.1

General Results

The primary intent of this study was to test the relationship between a specific set of biophysical factors and the incidence of known archaeological sites with a view to aiding land management and planning. For the study area the model correctly locates approximately 74% of the recorded sites in just under 23% of the land area. The model produced a map indicating two zones of elevated likelihood for heritage sites. The predictive area is that which results from the intersection of thematic layers, where individual layers represent a single criteria. The high potential zone was the absolute intersection area of the input map layers, and the moderate potential zone was defined by a boundary area around the high potential area. The two areas of proposed elevated archaeological potential were coregistered with the map of known archaeological sites to evaluate the power of the model.

7.2 Discussion

The model utilizes commonly available biophysical data. TRIM data are produced by Ministry of Forests and Ministry of Environment. Archaeological data are not generally available to the public. It is, however, easily compatible with TRIM data and should be available for legitimate studies regarding heritage values.

The determination of input criteria for the model was influenced by many sources. First is the general concurrence among other models reviewed that slope, aspect, and proximity to water are critical factors in determination of suitable sites. This central set of factors is seen in archaeological studies in Canada, The Netherlands, Italy, and the United States. Secondly, personal conversations with the Lillooet Indian Band reinforced the validity of these factors. Finally, research into the anthropological history of the area indicated that these factors could be reliably used as locational determinants. Certainly additional specialized research in this area is possible, but would require extensive cooperation from the appropriate native bands.

Similarly, the methodology utilized here is an adaptation of procedures used by many professional researchers in British Columbia and internationally. An overlay system to determine areas where multiple criteria should have favorably influenced land use has been used to simultaneously reduce the area of high potential for heritage value.

In some cases, other models have adopted a weighting system for modeling factors. I have elected not to assign unequal weights to the criteria. This has been done for three reasons. First, it is my intention to avoid 'second guessing' the environmental preferences of prehistoric or historic peoples. I can make no better justification than this; while the model is built upon the assumption that environmental forces influenced land use, it is beyond the range of my knowledge to assign a hierarchy of importance to those factors, and occasionally archaeologists differ in their evaluations (Hayden, pers. comm [10], Barratt[11]). Regardless of the inevitable weight of presumption implicit in my equal weighting, I wish to make no unbalanced judgements. Equal weights seems to be the best place (for me) to begin. Secondly, it is reasonable to assume that many cultural factors and social preferences influenced traditional land use and settlement. Again, contemporary valuation, and especially my own valuations, of traditional preferences in the absence of reliable written or clear physical records seem suspect. Unless these values can

10 Simon Fraser University, Burnaby, 1997
11 The Lunt Roman Fort Archaeological Excavation, Warwickshire, England, 1995

become known factors, adding unsupportable cultural and social influences to the model confuses the process of discovery with the subsequent process of theorizing and explanation. This may however, be a matter of scale. In developing a landscape level planning model it is not reasonable to make the same detailed assumptions or to be as discerning as one might if doing a site specific study.

Finally, it was felt that the equally weighted intersection of factors would allow for the most explicit, and simplest, examination of the results of this work. Assignment and testing of a similar model with weighted variables is a reasonable task for subsequent study; anthropology and forestry disciplines working in a collaborative effort would be logical for this realm of work. Scott *et al.* (1994, appendix I.) does however conclude that " predictive modeling that is data driven does not allow weighting of environmental criteria based on an archaeologists' expert opinion". That being said, many other modeling reports did weight various criteria in producing final predictive maps.

In looking at the comparative results between any of the individual model criteria in relation to the archaeological data, one might be tempted to conclude that any single criteria of those used here is significant in relation to the presence of recorded sites. This may be true in some situations. However, prediction of heritage potential areas is only advantageous if the area of land so proposed is a substantially reduced subset of the overall area. Prediction of 100 percent of known sites in 100 percent of the available land area may be an archaeological or statistical success, but it is not of great planning or operational value. The methodology used here, whereby the intersection of relevant criteria indicates areas of potential, serves to quickly reduce the land area proposed.

Within the study area, 58 sites have been recorded. The portion of the study area indicated as of high and moderate probability by the model would include 43 of these. As noted earlier, both Archaeology Branch information and Lillooet Band anecdotal information suggest that additional sites exist (see Section One and Section Three).

The trial of the null hypothesis model using roads as a locational guide to sites adds to the context of this particular model. Imagining archaeological survey work being conducted along established roads is not at all extreme. Heritage management goals being applied to existing land areas might logically begin from roads. If this were the case, would researchers be equally effective in locating heritage sites from roads as if they used a model such as the one presented here? Within the corridor of 350 metres on each side of roads, a field survey crew would be asked to look at an area of over 6,800 ha. or over 42% of the study area. This contrasts with the three variable model which defines under 24% of the study area as of high and moderate potential. The road based survey would reveal 32.8% of sites. The three variable model would expose roughly 74% of the extant sites.

But one might also look at the coincidence between archaeological sites and current Indian Reservation land. The Pavilion Indian Reserve No. 1, seen in Fig. 7.1 at right, does in fact contain 19 of the 58, or 32.8%, extant sites, by coincidence exactly matching the road corridor test results. The area of the Reserve lands is approximately 847 ha. The land area of this reserve is 5.4% of the study area, making this test far

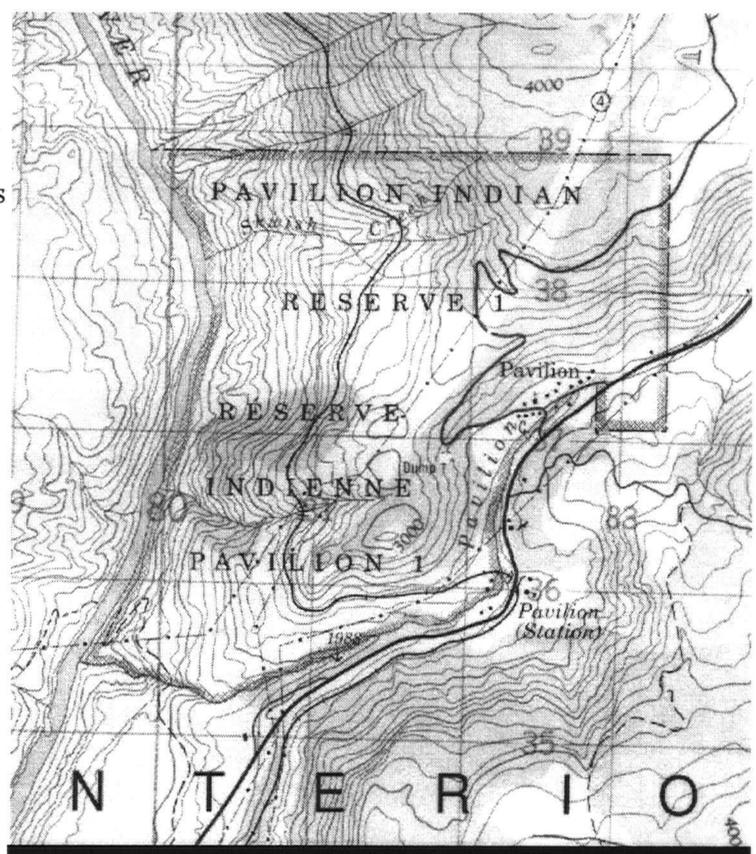


Fig. 7.1 Pavilion Indian Reserve

more powerful than either the thesis model or the road corridor test.

My suspicion is that this last test suggests a historical basis for the location of the Reserve land. It would seem logical that reservation land would naturally correspond to areas of extended use or habitation. a second possibility is that there may have been more attention given to cultural issues on reserve land, thus the much higher site to land area ratio. Alternatively, the possibility of a long period of continual native occupation of reservation land may have prevented the physical archaeological record from becoming obscured by natural processes or destroyed by modern agriculture or road construction.

In the absence of relevant political boundaries or several generations of road work one would not have such convenient guides. Therefore I suggest that a land management model displays its value not just in the number of sites encompassed by the highlighted zones, but in the exclusion of archaeologically non-productive areas. To substantially and accurately reduce the area of land which would otherwise need to be intensively surveyed is, in my opinion, most valuable.

The various histograms of cell values for known sites in Section 6 suggest that the criteria cutoff limits used by the model are individually inappropriate to indicate areas of archaeological significance. In combination, however, the model criteria as presented are fairly successful for the subject area. Slope, for example, would require a 29% cutoff to individually return 74% of sites, in contrast to the model cutoff of 15%. This does not mean to imply that this model is complete and leaves no room for improvement or refinement. Indeed, I believe that many quantitative and qualitative systems could be applied to this work. Source data quality, as discussed shortly, would, I believe, remain an issue however. Quantitative methods are not my strength, nor did I intend to to make that the focus of this work.

As noted in section 6, some version of a distance to water variable is used (admittedly with a broad range of values) by every model reviewed directly or referenced by others. The limit of 350 metres used for this study was suggested by the Lillooet Tribal Council members. Although the distance to water criteria does not present itself with a rigorous basis, one straightforward observation regarding this factor is interesting: the standard deviation of distance to water values is 313.89, well in excess of the mean of 266.64. Nevertheless, the mean is not much in excess of one cell short of the model criteria limit of 350 metres. Recalling the results of the model testing, 74% of the known recorded sites are located in the high and moderate potential zones identified. In fact, the portion of the study area within the 350 metre buffer on each side of definite watercourses contains 39 sites, 67% of the extant total.This does suggest that proximity to water does have a substantial impact on the original model (B. Klinkenberg, draft review, 2000).

During the course of revising the draft versions of this paper, I consulted with the Statistical Consulting and Research Laboratory at UBC. The purpose of this was to obtain guidance in respect to statistical evaluation of the model data and testing results. Hubert Wong (pers. comm.[12]) performed this review. Many of his observations reflect upon the quality of the data, and are noted in the paragraphs following. It also is evident that meaningful statistical evaluation is beyond my experience and ability, thus I acknowledge that many potential aspects of interpretation of the results of this work are not covered.

I have noted in several places in this paper that the archaeological data provided to me for this work is very limited in its extent. These limits along with other unknown characteristics of the data limit the analysis which may be performed reliably. First, nothing is known about the collection methods used, and this is alluded to earlier in this section. The database for the recorded sites lists only the dates of information entry, not the date or method of discovery. We do not know if the entire area or a portion of the area was surveyed systematically, or if the discovery of

12 Statistical Consulting and Research Laboratory, UBC, 1999

one site encouraged researchers to explore for additional sites in adjacent areas. In addition, there appears to be no information on the characteristics of any site which would indicate importance or give any assessment relative to other sites. For some purposes, then, the archaeological data are of limited quality, being essentially a preliminary inventory as yet without elaboration; it is without any environmental component apart from mapping coordinates. Secondly, because we know nothing about the data collection, we also know nothing about any land not indicated as a known site. We cannot assume that any remaining area of the site is without archaeological or heritage value. As a result one cannot compare known sites with areas of known non-sites, because we cannot, with any confidence, assume that a site does not exist for any place within the study area. Known non-sites may only be verified by ground survey and exploratory excavation and might require the physical presence of artifacts or some other physical record, assuming the absence of native traditional use assertions. The Eldridge and Hoffman (1996) study for the Squamish Forest District mixes biophysical assessment with anecdotal information, resulting in a probability map which, in the words of Diane Reed, Squamish Forest District (pers. comm[13]) "...shows areas where there is no evidence of traditional use, but we have to put it on the map because they (the First Nations Elders) said that there was a trail there." Important note! This is in no way intended to criticize the project mentioned or to devalue the use of local or native opinion and knowledge. It is intended to highlight the difficulties that may occur when non-objective information is combined with conventional mapping techniques and 'hard' data. For more on this issue see *The Use of Local Knowledge and Expert Opinion in Resource Planning* (Lui, 1994).

Finally, Eldridge, who, with Mackie (1993), authored the report on predictive modeling noted on page 19 of this paper (Section three), notes in Eldridge and Hoffman (1996, pp. 13-14), **"Predictive modeling does not necessarily imply the use of so-called objective statistical tech-**

13 Squamish Forest District Office, 1997

niques to determine where archaeological sites will be found. In the simplest sense, a predictive model entails observing patterns of known archaeological sites across the landscape, and using that information to intuitively suggest where other sites will be found." (emphasis theirs), and "For most parts of the province, we do not know enough about site distributions to successfully employ complex statistical models. However, simple non-mathematical modeling often can be effective for identifying particularly sensitive areas, allowing further investigation prior to land-altering development."

I have discussed several issues related to the quality of the archaeological data provided to me for this work, and accepted the limits imposed by that data. Other data concerns must be acknowledged which are related to the methodology of this work. One primary area of data weakness concerns the use of contour data to build a digital elevation model. It has been pointed out to me that this procedure does lead to substantial distortions in the resulting data maps, and I believe that this is apparent in the banding of slope data in the slope maps in section six. Related to this is the tendency for locations of high or low points, which fall between contours, to be lost when a continuous data map is produced from contour data. As noted in section four, complete elevation data were not available to me for this work. In retrospect, however, the problem of loss of high and low point information could have been addressed by interpolating the elevations of subject locations, and the manual digitizing of pixels with those elevations. For this study, the contour interval was 20 metres, and so I would assume that this is the maximum extent of error in regard to high or low points, or to the masking of topographic features.

With the methodological work complete, two observations regarding spatial issues are noteworthy. The first concerns the archaeological data which were obtained as point data and converted to raster data. Point data, by definition, has no dimensional value; it is simply a point in a particular location. Archaeological sites do, however, occupy real, measurable space. As a specific example, the Keatley Creek pit house site is approximately four hectares in size. At a pixel resolution of 29 metres, the site should be represented by a cluster of 47 or 48 cells. The conversion process cannot translate non-dimensional point data into an accurately located pixel representation of any specific site. This magnitude of this problem will vary with each specific site; very small sites may indeed be over-represented by a single pixel. From a landscape level perspective, this problem may be a relatively minor concern.

The second concern regarding the spatial aspect of this work is the question of appropriate pixel size. When the source data were converted from vector to raster format, the resulting pixel size was 29 metres. I considered this to be acceptable, as it compares favourably with thematic mapper or multi-spectral satellite data which would typically be obtained with a pixel resolution of 30 metres.

Evaluation of landscape characteristics requires that data be both fine enough to preserve specific features so that they may be considered in subsequent analysis, and general enough so that erratic values do not cause distracting 'noise' in mapping. This may be an issue of scale; this work has not been directed at specific archaeological sites or specific landscape features. Looking at a landscape level analysis, though perhaps a small area of 'landscape', I consider that a 29 or 30 metre pixel size is too small. Minor variations in the source data seem to create unnecessary 'speckling' of the map data. For example, occasional pixels with slope values of 25% might appear in an area of slope values which range from 10 % to 15%. It seems unlikely that such a discrete variation is either accurate or important from a land use perspective. I refer again to the physical size of the Keatley Creek pit house site; four hectares of actual site is set in an area perhaps 16 or 20 hectares in area. If this model process were to be repeated I would rescale the map data to yield a pixel resolution of perhaps 100 metres.

Aspect was extracted from the base data into eight cardinal classes, rather than than in single degree increments (which was an option). Slope values would be better represented by a series of specific classes, rather than in individual percent increments. Slope was classed into 5 percent groups (see Fig. 6.12), but overlays with other criteria yielded areas which were so small and fragmented that I considered them to be unuseable. The use of contour data rather than proper spot elevation data may be partly responsible for this problem.

Distinct from the physical information is the cultural support information provided by members of the Lillooet Tribal Council. The Lillooet Band has inhabited the present day Lillooet area for generations, and, through personal interviews, provided anecdotal information about the area, historical inhabitants, and traditional land use habits and patterns. Council staff were briefed on the intent of this work, and their opinion was sought regarding this modeling exercise. Based upon the expected results, staff concurred with proposals for the study area and the modeling criteria used here. As I listened to the conversation of the Council staff discussing this study, it was my opinion that their knowledge of the land and archaeological and/or heritage sites which exist is quite different from the information contained in Archaeology Branch records or academic literature.

One further refinement which was anticipated was to examine the predictive power of the model specifically for sites of long term or repeat use habitation sites. Additional information regarding the presence an distribution of habitation sites was requested from the Archaeology Branch, but this information is not available; it does simply does not exist in the CHIN database (see Appendix Five). In as much as other researchers have noted the lack of good (or desirable) quality environmental data in British Columbia (Eldridge and Mackie, 1993), it appears that many ideas for refinement of predictive models will be affected by the quality of the archaeological data as well.

While this work has not yielded information regarding prediction for specific site types, there is value in a general predictive exercise. Heritage resource management would evaluate any site in consideration of its cultural, educational, scientific, or economic value. Considered in this light, all sites are of equal value in terms of discovery and preservation and therefore all heritage sites are of equal value.

One area of interest is the absence of sites in areas identified as high potential. Ground survey in these areas is the only method available to provide additional archaeological information in these areas. Further coordinated work with the Lillooet Indian Band could also provide additional information for specific sites or areas. As noted in section two, current thinking in this field suggests that many more sites are likely to be present. Archaeology Branch staff note "The archaeological site information provided to you represents what has been formally recorded and submitted to this office. Since most areas of the province have not been systematically investigated, it is highly probable that other unknown and unrecorded sites exist within your area of interest" (Pradeep Singh, pers. comm[13]).

Another aspect of this area that may bear further examination is the spatial relationship between sites. Many examples of this type of study may be found, and in conjunction with focused field work, would lend itself to site specific statistical examination. Finally, the relationship between site locations and specific topographic or geomorphologic features seems very intriguing. This aspect of the study area becomes visible when the site locations are superimposed with a shaded relief map of the area, as seen in Fig 7.2 following.

In Fig 7.2, the known sites are indicated in red. The Keatley Creek site is the green square at lower right. The summary of all study area sites in Fig. 6.61 does begin to examine this issue.

13 Archaeology Branch, Victoria, 1997

Looking at Fig. 7.2 one could make several observations. The first is the clear importance of the rivers to historic land use. Pavilion Creek and Pavilion Lake to the east (not seen in the study area) along with the Fraser River give the appearance of 'magnetically' attracting archaeological sites. The terraces along the river also appear to be site-suitable.

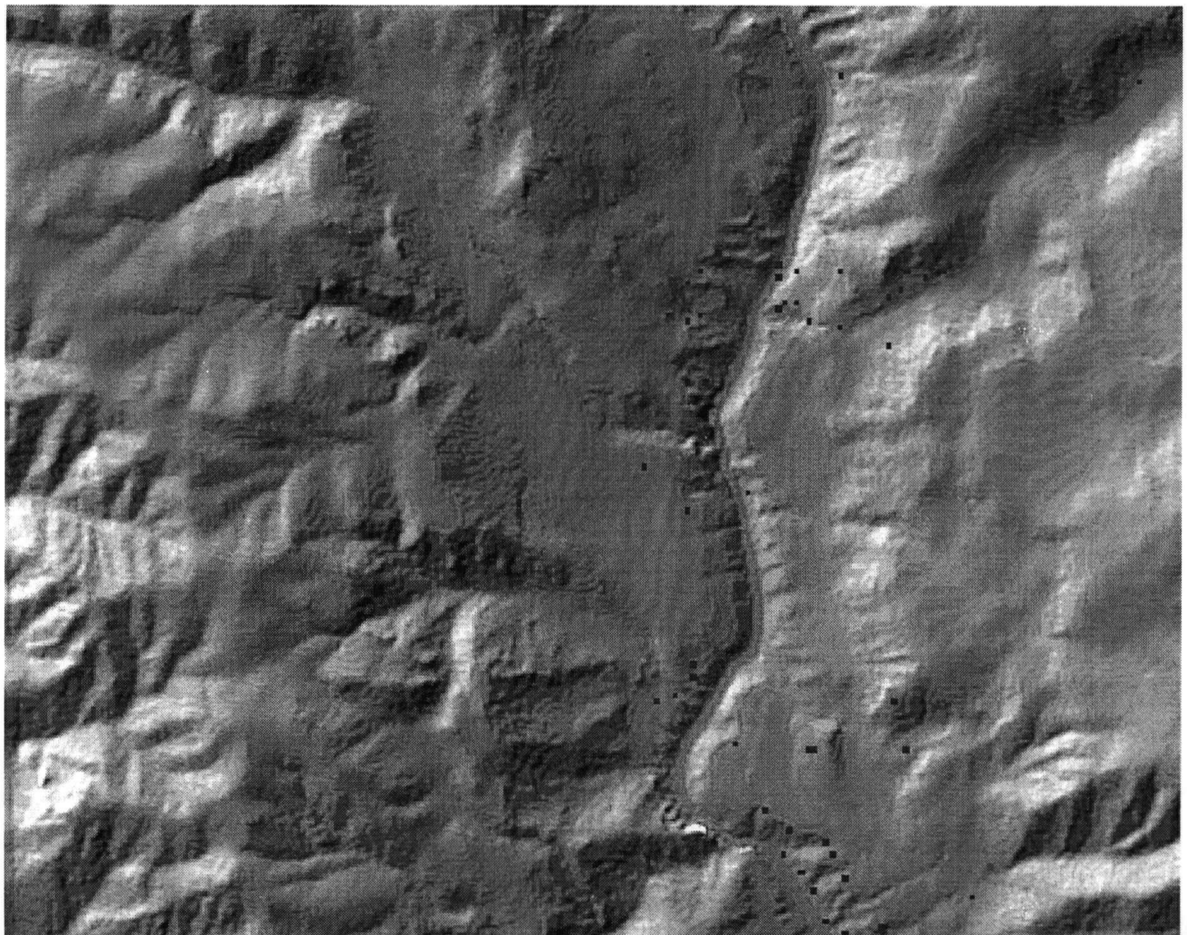


Fig 7.2 Known Sites Over Shaded Relief Map

A second observation is that the distribution of recorded sites may be a function of the current level of archaeological knowledge about the area. As noted earlier, this may reflect on the discovery and recording methods used to date; the current record cannot be a complete or final recording of the resource.

There does appear to be some spatial clustering of sites within the study area as well. Approximately midway along the Fraser, in the centre of Fig. 7.2 is an area with only one recorded site. Further, from the area generally west of the Keatley Creek site, the east bank and terraces are empty of sites all the way to Pavilion Creek. Having travelled through the study area I suspect that the construction of roads, railways, the hydro transmission line and extensive agricultural development have destroyed most of the archaeological record in this portion of the study area.

It is important to reconsider the aim of this work: to develop a pre-operation, planning and management model. This model has achieved a predictive accuracy of 74.2%. Based on reviewed literature, this is well within the range considered a success by other researchers. Its role may well be to define 'where do we begin'.

SECTION EIGHT

CONCLUSIONS

8.1

Evaluation of the model developed and tested in this work may not be reduced to a single, simple answer. In discussing this work with others it raises many questions which would be answered by additional research. Archaeology and heritage resource management themselves are, in my experience, often concluded with interim assessments; it is a case of 'what can we conclude given what we know at this time'.

The successful testing of this model is demonstrated by the 74.1% of known recorded sites being within the areas proposed as having an elevated likelihood of containing archaeological sites. Concurrently, the area so proposed for archaeological value is 22.8% of the study area. This is, in my opinion, as important a measure of the usability of the model as the correct identification of historically valuable areas. The zone of high probability which was based upon the strict intersection of indicator cell values alone is less successful than the combined high and moderate potential zones; the high potential zone contains only 5 sites (8.8%).

The development and testing of this model was intended to provide answers to the following points:

• **Develop a model which uses widely available data.**

This work demonstrates that TRIM data as supplied to private and public groups can be utilized for predictive modeling and historic potential values. Archaeological data are not normally available to the public, but should be obtainable for legitimate study or planning.

- **Produce a reliable archaeological planning model.**

With the data obtained, this thesis has demonstrated that planning maps may be produced and made available for distribution to forest planners and operators. The success of the model is aided by the environment of the study; dry interior zones with variable forest cover are clearly more suitable to a model of this type than densely forested coastal zones. The substantial reduction of land proposed as high potential is, however, a strength of the model.

- **Evaluate a limited set of modeling criteria as key indicators of archaeological site potential.**

A graphical overlay system utilizing an intersection method is effective in archaeological prediction, and the criteria selected appear to be appropriate for prediction in this situation. The results here are consistent with referenced work by others.

While I am pleased with the results of this work, I do not propose this as a universal model for all areas, nor do I feel that all aspects of this process are ultimately developed. In mapping the criteria and evaluating the resulting maps, it is apparent that additional work on the refinement of the criteria and their classification would be very interesting. At the same time, however, the quality of the TRIM data as well as of the archaeological data must be considered. This aspect alone is worthy of a complete study. Many issues related to mapping and map resolution deserve further study, and relate to the quality of input data available. As noted in Section Six, more intensive analysis of the data is likely limited by the data used here.

The distribution of heritage sites appears to be related to biophysical characteristics of the land. Further refinement and development of the methods used here should favour the practical application of planning models such as this work to heritage resource management.

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SECTION NINE

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SECTION TEN

APPENDICES

10.1

Appendix One

Notes of Ethnoarchaeological Site Types

by Muir et. al (1994)

Environmental zones in the Kamloops LRMP

- River Valleys: land less than 500 metres from the river bank and less than 60 metres above the river. Fishing, some hunting in winter, and social activities are proposed traditional activities.

- River Terraces: all terraces above salmon bearing rivers and less than three kilometres from the river bank and more than 60 metres above the river. Winter Villages, food-gathering base camps, and food storage and processing sites are expected traditional activities.

- Intermediate Lakes: land adjacent to mid-altitude lakes (less than 1500 metres), and generally in more open areas of Interior Douglas Fir (IDF) and Interior Western Hemlock (IWH) zones. Some winter habitation sites may be expected, by primarily food-gathering base camps, food processing sites, or earthworks such as hunting blinds.

• Intermediate Grasslands: Generally between 1000 and 4000 metres, and less common in IDF and IWH zones in this area. Seasonal food-gathering should result in small, short term base camp locations.

Montane Forest: continuous canopy forest areas of IDF and IWH, at elevations of 600 - 2000 metres. Muir et al. report that use of landscapes of this type was minor and casual, with occasional resource procurement, and transit to higher elevation meadows and parkland environments. Scattered physical evidence is expected at best.

10.2 Appendix Two

Interior British Columbia Pre-History

The recent history of British Columbia dates from the early Spanish, French and British explorers of the 18th century. When visited by the early naval expeditions, the present area of British Columbia was inhabited by native peoples whose range covered most of the province, and whose history of habitation and use dates from perhaps 12,000 years B.P. (Fladmark, 1986).

The prehistory of British Columbia is generally divided into chronological cultural eras. Coastal peoples are ranked separately from interior peoples, but each are broadly subdivided into early, middle and late periods. For the interior peoples, the Early Period is generally accepted to begin 12,000 to 10,000 years before present and continue to perhaps 8,000 years BP. This period follows the retreat of glacial ice, and the advent of a warming climate. Currently, the earliest archaeological sites are located in the north of the province. The Charlie Lake site near the present town of Fort St. John, has cultural deposits dated to 10,500 years BP (Hayden, 1992). Logically, the Peace River area , east of the Rocky Mountains, contains the oldest recorded sites as an ice-free corridor existed in this area during the last ice age (Fladmark, 1986). It is interesting that northern continental archaeological sites are generally similar in age to the oldest of sites known in both the southern United States as well as in Central and South America. Clovis man, considered to be one of the earliest peoples in North America, and most significant because of their lithic technology, is currently dated to 11,500 BP (Hannen and Kelley, 1988). Remains of Kennewick Man, a nearly complete skeleton found in Washington State, believed to be of the earliest hunters in North America, are dated as 9,200 BP. Farther north, the Bluefish Caves in central Yukon are similarly dated to approximately 11,000 BP.

The Middle Period spans extends from 8,000 BP to approximately 4,500 years BP. This period saw the gradual cooling of the climate, and the expansion of the ranges of coniferous forests (Hayden 1992). Substantial archaeological remains exist from this period, although not for the entire period. The oldest radiocarbon-dated Middle Period site is the Drynock site (Fladmark, 1986). Located near Spences Bridge in the Thompson River Canyon, Drynock has yielded flaked-stone chips, a knife or stone point, and salmon and animal bones. Material from this site has been traced to a prehistoric stone quarry at Rattlesnake Hill near Ashcroft. For Fraser River Valley sites, Fladmark (1986) notes that the majority of stone tools and fragments have been chemically traced to a prehistoric basalt quarry in the Arrowstone Hills near Cache Creek. The distinction between quarry sites and the find locations is important, suggesting travel along the major rivers in the region. This idea of the major river valleys as traditional trade routes is supported by Chief Terry Porter of the Bonaparte Indian Band at Cache Creek (pers comm[15]).

The Late Period in the interior region is classed as the last 4500 years, leading up to European contact. It is from this period that most of the physical archaeological material may be dated. "Pits, pipes and pictographs", as described by Fladmark (1986). He suggests also that this period displayed trends of increasing cultural diversity in the interior, matching roughly the progress made by coastal peoples. This diversity included larger and more permanent settlement sites, more complicated cultural organization, and more variation between communities in adjacent river valleys.

One of the most distinct physical imprints of prehistoric peoples is the pit house dwelling of the interior and plateau areas. The Keatley Creek pit house site is considered one of the most significant sites of this type in the Province (Hayden, 1992). Based on research and excavations by Hayden, this site was in use from approximately 2500 BP to 700 years BP.

15. Hat Creek Ranch, 1997

Fig. 10.21 Keatley Creek Pit House Site

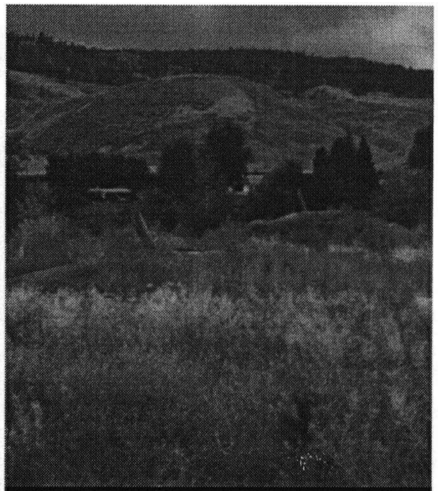

Fig. 10.22 Modern Pit House Reconstruction,

Photographs by the author of extant house pits at the Keatley Creek site are seen in Fig. 4.26 Section 4. Fig. 10.21 provides another view of the Keatley Creek Site. Fig. 10.22 shows two reconstructed pit houses at the Secwepemc Native Heritage Park in Kamloops. These are modern reconstructions of traditional pit houses, built using traditional methods and materials.

The pit house was typically about twenty five feet across and four or five feet deep (Hayden 1992). The pit is covered with four to eight heavy rafter poles sloping towards the center of the roof. A smoke-hole and door were left open in the center of the roof. The rafters were covered by boughs and sticks, and these covered with earth and sod. An entrance at ground level was also provided, with men generally using the roof entrance, and women and children using the side entrance. The photograph (by author) in Fig. 10.23 shows the interior of a pit house. The sleeping shelf around the perimeter of the interior is seen, along with the roof structure and notched roof access pole. Fig. 10.24 and 10.25 show an adaptation of pit house sketches from Teit's notebooks (Fladmark, 1986).

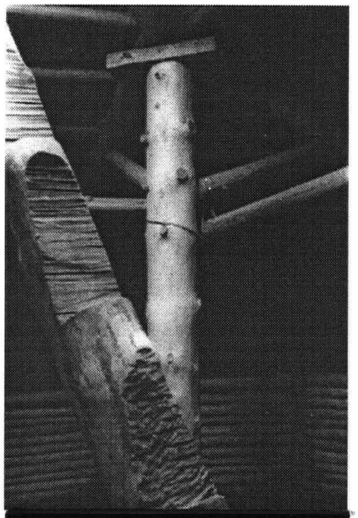

Fig. 10.24 Modern Pit House Interior, Hat Creek

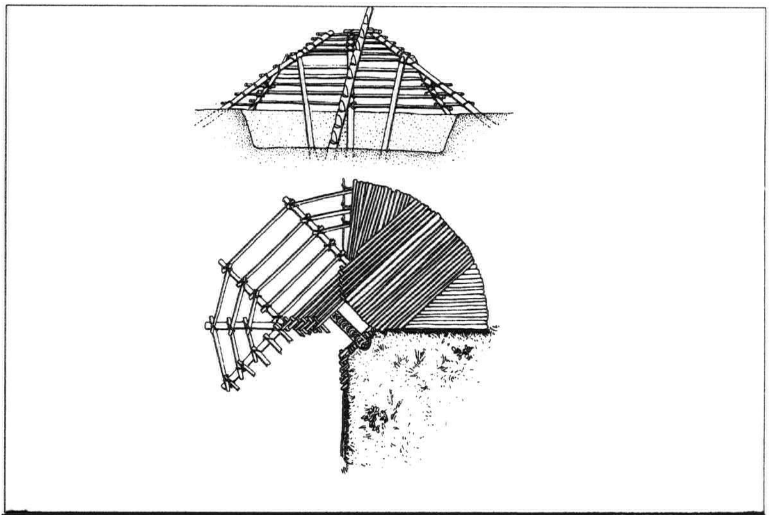

Fig. 9.25 Pit House Sketches, Adapted from Teits Notebooks

The building of a pit house and attendant food cache pits and cooking pits required significant effort. Construction would take three weeks to two months. Once built, pit houses were used every year, and would last for thirty years. As such, locations of pit houses were carefully considered (Daniel Gaspard, pers. comm. [16])

The oldest pit house depressions known are in northern California, and are believed to be 5000 to 6000 years old. The oldest in British Columbia are at the Mauer site on the south coast, possibly 4000 to 5000 years old. In the interior of the Province, pit house sites have been dated to approximately 3500 to 4000 years of age (Fladmark, 1986) .

The Late Period coincided with a general cooling of the climate. Hayden (1992) considers the expanding use of pit house dwelling to have developed in logical association with the cooler climate, the expanding population and developing culture, and the growing importance of salmon as a staple food resource.

16. Daniel Gaspard, Hat Creek Ranch, 1997. Member of Bonaparte Indian Band

10.3 APPENDIX THREE

Deductive versus Inductive Models

It is relevant to distinguish between models designed to deal with archaeological artifact data, and those concerned with spatial prediction and analysis. Models primarily concerned with archaeological data have been termed Inductive models (Dalla Bona, 1994). These inductive models are based on archaeological data taken from samples of archaeological artifacts. Assuming that similar conditions exist over a wide environmental area, prediction is an extrapolation of the known artifact data and interpretation. Prediction may be spatial, but is directed primarily towards the discovery of additional artifacts or artifact of specific characteristics.

Kohler (1986) notes that much existing work in North American models is based on this system. He suggests that because many areas of North America have extensive archaeological databases and accompanying site-related data, many intra-site inferences may be made.

This type of artifact-based model seems most appropriate in assisting in the accumulation of additional artifacts. My own experience in England, working on the the excavation of the Lunt, a first century AD Roman military fort, used this type of data collection and modeling assessment, and is an appropriate example. Briefly, the site was excavated using hand tools-a slow and meticulous process. As each artifact was uncovered, it was given a specific number, and its location recorded in three dimensions. Information about its, size, composition and condition were recorded. For each artifact record, the computer database linked a spatial reference with specific artifact characteristics. Observing only the spatial picture of artifacts, one could clearly see patterns in distribution, both horizontally and vertically, of the small finds collected thus far. Queries on the database allowed for spatial patterns of specific arti-

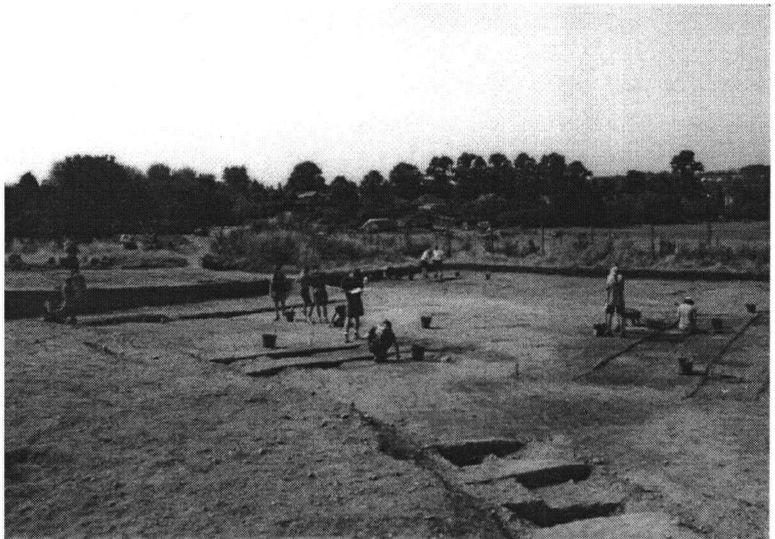

Fig. 10.31 Excavations (with author) at Lunt Roman Fort, England

fact features to be extracted. The inductive modeling process, based on thorough artifact records, would be expected to predict where additional finds of any particular artifact type would be expected to occur, and with what frequency. At the Lunt Fort (Fig. 10.31), this site specific information suggested a spatial layout to the fort, indicating the probable extent of various fort features. Specific characteristics of artifacts aided in the determination of particular periods of the forts construction.

Models aiming for prediction of unknown resources at a landscape scale are considered to be deductive models. These models are based generally on the assumption of a fundamental relationship between prehistoric land use and environmental factors (Dalla Bona 1994, Warren, 1990). Manipulation of criteria is the basis of prediction; areas of varying degrees of proposed suitability are determined by combinations of specific criteria. This approach is spatial on a large scale. Knowles (1974) has used this approach; general landscape characteristics were used to predict specific site locations, although his work was not intended as an archaeological exercise exclusively.

10.4 APPENDIX FOUR

CHIN database fields:

ZBN= Borden Unit

ZUB= Upper Borden Unit Letter

ZLB= Lower Borden Unit letter

ZSN= Borden Unit sequence number

ZRN= Temporary recorders number

ZER= Errors, corrections, changes

ZNA= Site name

ZLOC= Site location

ZACS= Access to site

ZTY= Site type (general), eg, Habitation

ZTYI= Investigators site type, eg, Pithouse

ZTYC= Prehistoric, Historic or both

ZLAT= Latitude

ZLNG= Longitude

ZUTM= Military grid unit

ZUTME= Military grid unit, east value

ZUTMN= Military grid unit, north value

ZAIR= Air photo

ZMR= Map reference to 1:50,000 National Topographic Series

ZLEG= Legal information, lot number, etc.

ZOWN= Land Owner

ZDS= If designated site

ZTP= Township

ZR= Regional District

ZCU/ZELG= Native band language area, traditional use area

ZDAT= Age of site if prehistoric

ZDATA= Source of site age, et Carbon 14

LU7= Details of dating, eg, lab sample, type of material

ZPER= Age of site if historic

LU8= Details of historic dating, eg. gravestone, newspaper

LU3= Elevation in meters

ZELA= Elevation

NR= Natural region

ZFE= Features at site eg, depression, mound

LU9= Details of features, dimensions, etc.

ZCON= Present condition of site

ZCONA= Future condition, eg, factors that will affect site

ZVEGM= Major vegetation type, eg. Coastal Douglas Fir

ZVEG= Vegetation found on site

ZDRMI= Drainage, minor to major

LU2= Landforms

ZPN= Permit Number of investigator

ZUPR= Unpublished references

ZPRF= Published references

ZPHO= Photographs taken (names, affiliation, roll number)

ZIN= Informant

ZRES= Researcher

ZRESD= Date of researcher's visit

ZRESC= Surface collection made, (names, affiliation, dates)

ZRET= Tested (names, affiliation, dates)

ZREE= Excavated (names, affiliation, dates)

ZCOL= Collection made (names, affiliation, dates, details, repository)

LUI= Significant artifacts collected or noted

ZRA= Research activity (observed, recorded, tested, etc.)

ZREM= Remarks.